

C Y C L E S

- A MONTHLY REPORT

OCTOBER · 1950

FOUNDATION FOR THE STUDY OF CYCLES

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CYCLES-A MONTHLY REPORT

Vol. 1

October • 1950

No. 3

The Director's Letter

Dear Member:

People often ask me, "Have you modified your views in regard to what is ahead for business?"

Very definitely, yes. As this letter is being written (August 15th) the Korean War is burning briskly. Billions of dollars' worth of military supplies are being ordered. Production is surging forward.

In other words, to mix metaphors, the hurricane is upon us. We may expect some of the normal tides to be temporarily overwhelmed. In many things we must expect a flood where ordinarily there would be an ebb, and in some things we must expect the reverse situation.

"If this is so," is sometimes the response, "what is the use of knowing about normal cyclic behavior, just now?"

Even with a war upon us, it seems to me that there are four reasons why it may be fruitful to know about the normal economic cycles.

One, if Russia were to about-face temporarily—and stranger things than that have happened—and we were faced with the collapse of our war boom, it would be valuable to know the levels of our economic activity called for by normal cyclic behavior, for it is to these levels that we might be expected to return.

Two, the only way we can know the extent of the war distortion is to know what would

have happened if there had been no war. To illustrate this fact I might mention that one of our great corporations made excellent forecasts of postwar behavior as follows:

First they computed normal cyclic production during World War II. Then they compared actual production of civilian goods during the war with these cyclic estimates, to discover civilian shortages. These calculations gave them an estimate of pent-up demand unobtainable any other way. Then they projected the normal cycles into the future, from 1945 forward. This gave them what production would presumably have been if there had been no war. Then they added to this normal production estimate enough to make up the war shortages disclosed by their earlier analysis. Finally, they added additional amounts to cover the effect of our government's deficit financing.

The point of all this is that the normal cyclic pattern was the basis of the entire study, both during the war and after the war, and that increased knowledge of cycles can help us, even as it helped them, in a time of confusion like the present.

Three, some of the cycles—particularly the shorter ones—keep right on manifesting themselves, war or no war. For example, the 9.18-month rhythm in the ton-miles of the Canadian Pacific Railway was not at all affected during World War I and only moderately distorted during World War II. Other short term cycles behave the same way.

And four, even during the cataclysms of the past, the cycles in certain series of figures have continued, seemingly but little affected. I refer particularly to the stock market.

These four reasons are, I think, ample justification for keeping up with a knowledge of cycles in spite of the war. And anyway, the war might be over someday, don't you think?"

"Well then, suppose there had been no war, nor, during the last several years, any fear of war," some questioners have continued. "Have you learned anything about cycles that would lead you to change or modify the projection of the normal cycles as made in the book *Cycles, —The Science of Prediction* written by yourself and Mr. Dakin in 1944?"

I have not learned anything that would cause me to change the timing or the amplitude of any of the cycles reported upon; but I have learned a good deal about many other cycles. Some of these other cycles have an important bearing on the general picture.

Let me give you details:

1. **The 54-year rhythm.** I now have reason to believe that the 54-year rhythm in production comes earlier than the 54-year rhythm in prices.

In other words, although the most careful work I have so far been able to do continues to date the low of the ideal 54-year cycle in **prices** at about 1952, work that I have done recently on various **production** figures would seem to date the low of the ideal 54-year wave in production at from 1933 to 1941, depending on the series.

It is very hard if not impossible to date these longer cycles accurately, because in most instances, the figures are available for so short a period of time, relative to the length of the cycle, but it looks to me as if in the production figures I have studied, the last decline ended in the middle and late '30's. If this is true, the underlying wave is already on the way up and is due for its next ideal crest in the early 1960's; its

next low in the late '80's. However, let me repeat, this observation in no way changes the findings in respect to the 54-year wave in prices, reported upon in the book *Cycles*.

2. **The 17 2/3-year rhythm.** In addition to the 18 1/3-year rhythm present in a number of series of figures, I have increasingly come across a rhythm that seems to be about 17 2/3 years in length.

If you take liabilities of commercial failures, reversed, as the basis for your dating, you find mid-1946 as the date of the last ideal low, and 1955 the date of the next ideal high.

This rhythm appears in certain prices, and in certain sales measured in prices, as well as in the sun, but seemingly it is not present at all in construction or real estate. It therefore does not serve to explain why construction has failed to go down in accordance with the normal 18 1/3-year pattern, but it does throw light on certain aspects of the general situation.

(If I may be permitted a conjecture, building activity has remained at high levels because of (1) government inspired easy building money, and (2) rent control laws. Demand for rental space is elastic. When people can get space cheaply they take more of it. This forces new construction to take care of people who cannot get the low rental space. I believe that if all rent controls were completely eliminated, and time allowed for adjustment to the new situation, we would find that we had more than enough housing space to take care of all our people at better than 1939 standards of occupancy. However, in voicing these opinions, I am getting out of my role as cycle analyst.)

3. **The 11- and 12-year rhythms.** I continue to run into rhythms of about 11 and 12 or 12½ years in length.

I do not yet know if they are real, or, if so, what is their exact length or exact timing. However, if they are real, they are helping to hold things up at the present time, in contrast to 1932-33 when they, as well as the 18 1/3-, 9-, and 6-

year rhythms, were all reaching for a bottom together.

4. **The 8-year rhythm.** I run increasingly into an important rhythm of about 8 years in length which is in an upward phase at the present time, and will be until 1952. The cigarette story in the current issue is a good example of this cycle.

Summary: If you have read **Cycles—The Science of Prediction** and followed the various reports that have been issued since, by the Foundation for the Study of Cycles, you will recall that it has been stated time again and that the 9-, 6-, and 18 1/3-year cycles, all now in a downward phase, had been approximately together at trough in 1933, 1914, 1896, 1878, 1860, etc.; that at some of these times the depression had been deep, at other times mild; and that there was as yet no way of knowing whether the depression ideally due in 1951 or '52 would be one way or the other.

By now, however, I think that enough evidence has accumulated to justify the conjecture that, even if there had been no war, nor preparation for war, nor deficit financing, nor rent control laws, the depression of the early fifties would have been of less than average intensity rather than of more than average intensity. However, much more work needs to be done before we can be sure.

In telling you these things I may be beating the gun a little bit, but I want to take you into my confidence and tell you of the things we are finding out just as soon as possible. The detailed reports will follow as fast as facilities permit.

Significance of the October Report

Here at Foundation Headquarters we refer to the memoranda in our monthly reports as "stories." Why did we select the stories in the current issue? What were the reasons for printing them? What is their significance?

The automobile story, the lead story in this month's Research section, was written for four reasons:

1. The automobile industry, involving directly over a million workers and purchasing several billion dollars' worth of materials and supplies, affects every one of us, directly or indirectly. A cycle in this great industry which averages over 30% rise or decline in three years' time is of the gravest national importance. It is a factor which needs to be understood by all concerned with the forecasting of our economy. **And it needs to be controlled by business if we would avoid government intervention.**

2. The automobile industry gives you an excellent example of the 6-year rhythm which is so common in American business and about which so little has been written.

3. The 6-year rhythm present in automobile sales is also present in natural as well as in economic data. A knowledge of it may help to determine the cause of these important economic and biological disturbances. When we have determined the length and timing of the 6-year rhythm in all these various series of figures with enough exactness we will have a better idea as to the extent to which the phenomena may be interrelated.

4. The fourth reason for the writing and inclusion of the automobile story is to pave the way for another story about the 11- or 12-year rhythm in automobile sales. If you adjust the automobile figures for the effect of the 6-year rhythm, an important 11- or 12-year rhythm appears. One wave of this rhythm was at trough about 1933. The ideal pattern is therefore due to crest about now. If this rhythm is continuing it is exerting an upward force at the present time which may be expected to minimize the downward force of other cycles due for lows now or in the near future.

The lynx story was included for three reasons.

1. It was included partly to show you how well the behavior for the past 214

years fits an ideal 9.6-year pattern. (Did you ever see a prettier cycle?)

2. It was included to give you a new index of abundance, developed especially for the purpose of cycle length determination.

The 9.6-year lynx cycle needs to be measured as exactly as possible. The more precise our measurements of a cycle, the surer we can be that another cycle of about the same length is or is not related to it. That is why ever more and more exact measurements are necessary. But exact measurements depend upon homogeneous figures.

I had intended to make a more exact determination of the length of the lynx cycle and to publish the results in this issue, but time did not allow. I therefore decided to let you have the figures anyway so that you could work on it yourself if you wanted to.

3. The third reason for giving you the lynx story is the fact that hints of two other cycles in these figures have been uncovered. I wanted you to know about them. These other cycles will be pinned down and definitized in later reports.

The bird story was inserted to give you an example of one of the extremely common biological cycles. As you have learned from Foundation Reprint No. 32, mailed to all contributing members last month, you and I also have a daily cycle of temperature variation.

The story regarding seasonal patterns of crime, insanity, and suicide gives you another example of the workings of the annual cycle. These cycles affect us all, but as their length is known exactly, and their ultimate cause also, the details involved are more the subject matter of sociology or of physiology than of the science of cycles. But still, they are interesting to know about.

The cigarette story was included for two reasons.

1. Not much has been written about the 8-year rhythm, in spite of the fact that it

is really quite important. It was reported upon first, as far as I know, in **Generating Economic Cycles**, by Dr. H. L. Moore of Columbia University. This book was published in 1923. In cigarettes at least, as you can see, the 8-year rhythm has been coming true ever since.

2. The 8-year rhythm is due for a crest in 1952 at about the time when many other rhythms are due for a trough. This is contrary to the situation in 1932 when a trough of the 8-year rhythm coincided with the troughs of other rhythms. This fact has important implications for the future of all businesses which are directly or indirectly affected by this rhythm.

In the **Technical Department** this report carries the second section of the memorandum **How to Get Hints of Cycles**. This story is really a reprinting and expanding of Foundation Technical Report No. 1, now out of print.

One reason for including it is given by the title. But the inclusion of the story has a deeper purpose: It was written and printed to try to drive home the fact that no one of the ways commonly known provides more than a start toward a rhythm analysis. Many people do not realize that this is true and, as a result, come a cropper in their forecasts.

The **Bagno-Works synthesizer and analyzer** is described for the benefit of those who are interested in mechanical and electrical methods of cycle analysis. This story merely continues a story started last month as a report upon the summer meeting of the New York Chapter.

Questions and Answers are included for general information. The same of course applies to **Financial** and to **Additions to the Library**.

Very cordially yours,

Edmund R. Dewey

Research

Cycles In Automobile Sales

THE 6-YEAR RHYTHM, 1893-1949

The sales of automobiles—from Duryea Brothers' first gasoline driven motor vehicle in 1893, to the present time—have been characterized by an important 6-year rhythm. If this rhythm continues, war or no war, sales in 1951 should be down.

Factory sales of passenger cars since the inception of the industry are plotted in Fig. 1 and recorded in Table 1.

6-Year Pattern in Passenger Car Sales

You can see definite regularity in the history of these sales. The 6-year pattern in these figures has shown up without exception seven times from the beginning of the industry to the outbreak of World War II.

If you study Figs. 2 and 3 you can see the emergence of this pattern. The solid line in Fig. 2 shows you the actual data smoothed by a 3-year moving average, together with a 6-year moving average, or trend, indicated by a broken line. Fig. 3, based on the information in Fig. 2, shows you the 3-year moving average as a percentage of the 6-year moving average trend. Fig. 3 shows the 6-year pattern clearly and shows you what will happen in the future, relative to trend, unless something comes into the picture to break the pattern of nearly half a century.

I have indicated with a dotted line in Fig. 3 a perfectly regular 6 1/8-year repetitive pattern. This ideal pattern aids your eye to see deviations from perfect regularity that have been caused by

other influences. These might be other regular patterns, or non-recurring irregularities, or both. The conformity of the actual pattern to the ideal pattern is noteworthy.

Effect of the 6-Year Pattern on Sales

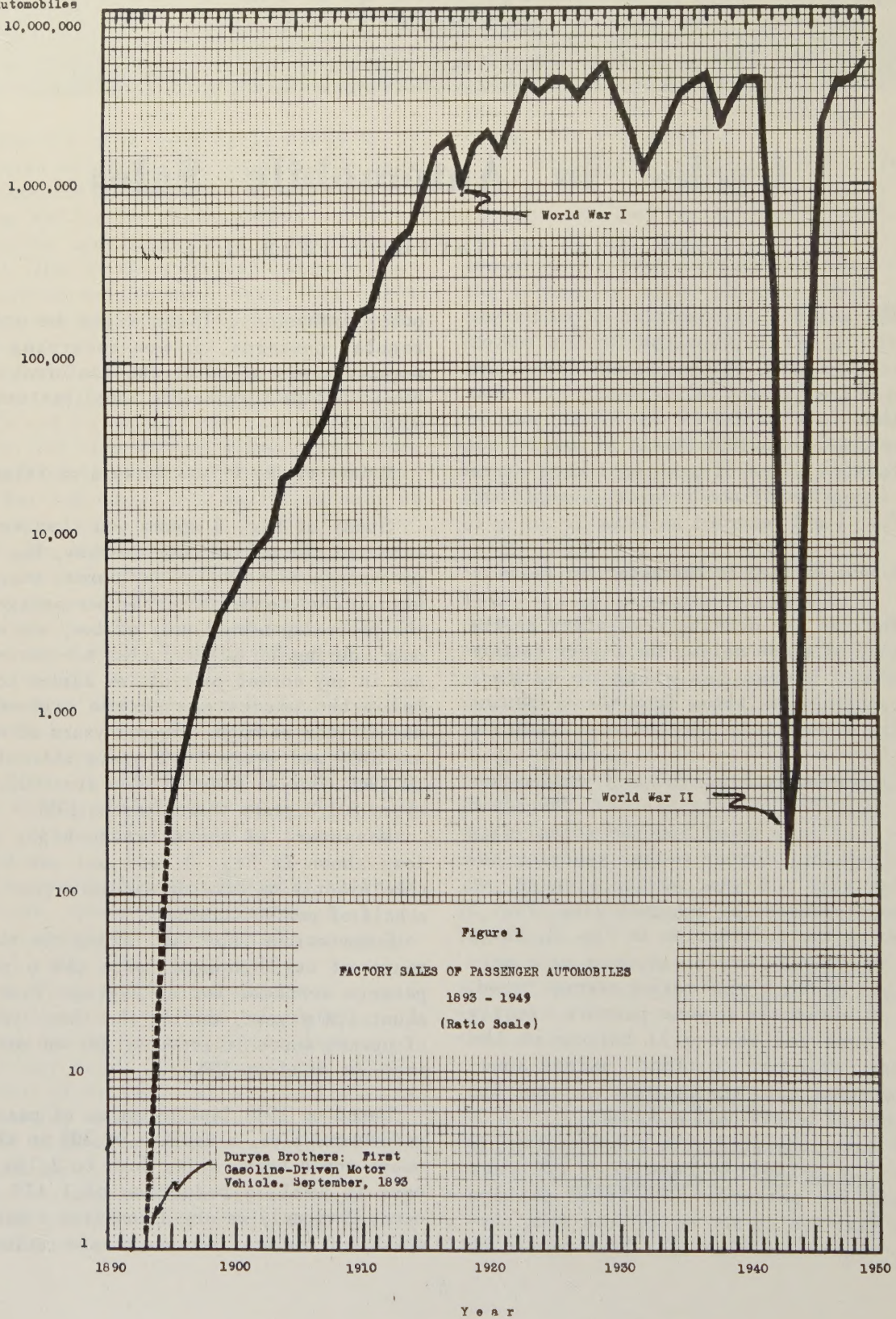
Study of Fig. 3 shows you that never once, in the period under review, has the percentage of trend in any normal year of high failed to be above the percentage in the preceding normal year of low; and only once, during World War I, has the percentage in any normal year of low failed to be below the percentage in the preceding normal year of high. (Normal years of high are 1899 and every 6 1/8 years thereafter to 1948. Normal years of low are 1902 and every 6 1/8 years thereafter to 1951.)

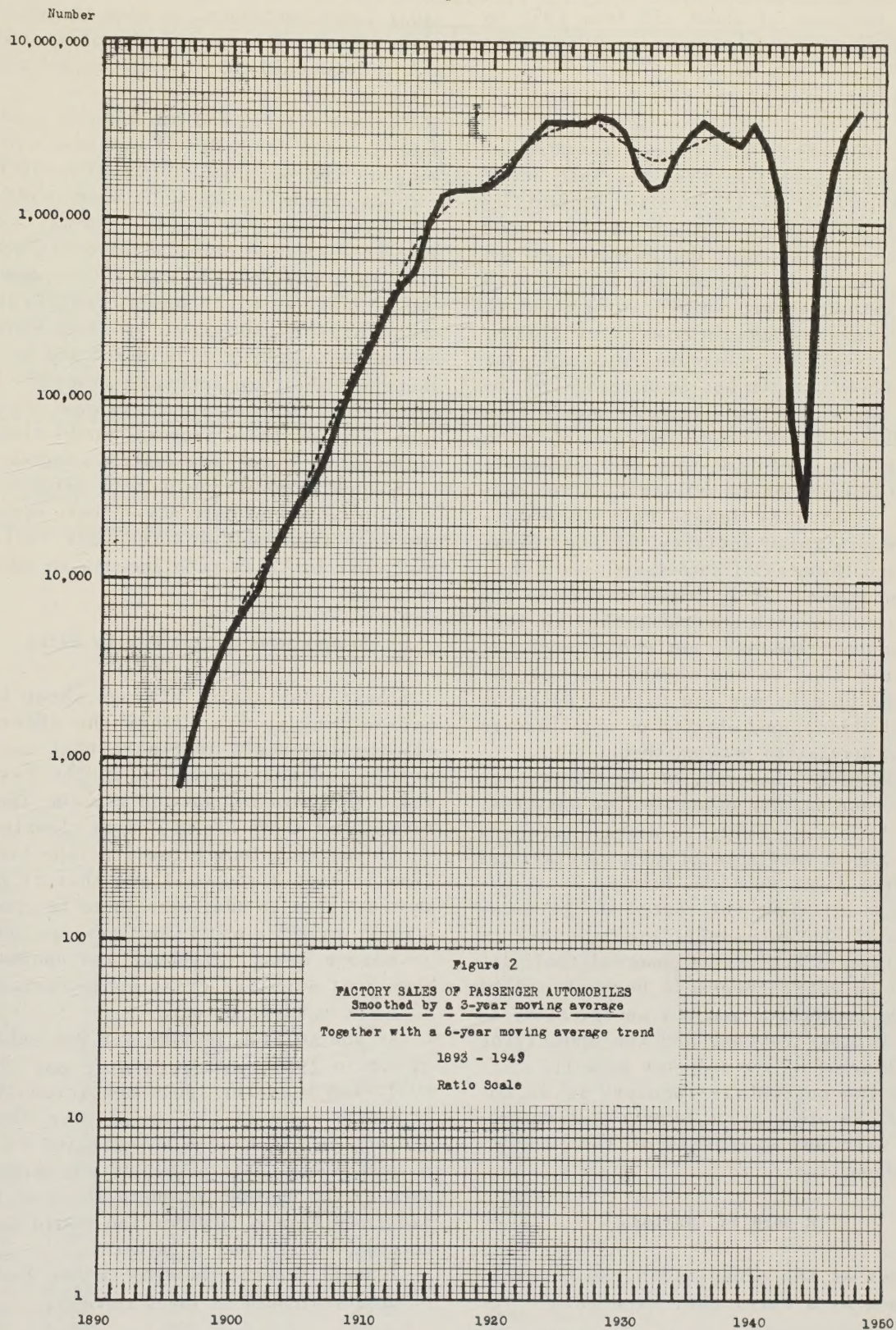
Moreover, of the thirteen highs and lows shown in Fig. 3, all but one have come exactly on time or within a year and a half of perfect timing.

Computations show that during the three years of its downward force the 6-year pattern accounts for an average loss of about 10% a year; during the three years of upward force it accounts for an annual increase of about 15%.

Based on 1948 factory sales of passenger automobiles, a decline of 30% in three years would bring sales down to 2,736,000 cars in 1951, a reduction of 1,173,000 cars. Obviously we are discussing a matter worthy of the most serious consideration.

Number of
Passenger
Automobiles
10,000,000





An increase of about 45% from 1951 to 1954 would bring sales back to 1948 levels.

Significance of the 6-Year Pattern

Granted that the 6-year pattern is there, you will ask, "Is it significant?" That is, is it "real?" Will it continue?

The internal consistency of the 6-year tendency in passenger car sales gives you every indication that we are dealing with a reliable pattern which can be used to make provisional forecasts of future probabilities. Furthermore, such a 6-year repetitive pattern has been recognized as being present in many other economic time series--some of them covering a much longer period of time than the automobile industry has been in existence. Also, patterns of similar length have been discovered in solar activity, in the thickness and thinness of successive tree rings, and in climate. It is possible that we are dealing here with something that is very fundamental. However, not enough work has yet been done to see whether or not the lengths of economic and natural patterns are identical, and whether or not there is any interrelation between them.

Regardless, however, of the reasons for the 6-year and for other similar patterns, many firms are coming to depend more and more upon a knowledge of such regularities to throw light upon the future. It is obvious that anyone interested in the prospects of the automobile industry has in this type of analysis a powerful tool with which to detect probable fluctuations of future production and, by subtraction, to detect other rhythms and the underlying growth trend of the industry as well.

As the automobile industry is so important we need this information in connection with any appraisal of the general situation, too.

A Word of Caution

Just as the ocean tides can be overwhelmed by a hurricane, even though the

tidal force continues, so also the repetitive 6-year pattern in automobile sales can be overwhelmed or modified by other forces.

We have already had one example of disruption, when World War II completely overwhelmed the pattern. If the Korean War spreads, or is followed by other similar outbreaks, the peak due in 1954 may likewise be distorted or eliminated. In addition this rhythm will surely respond to the influence of the underlying growth trend of the industry, if this should happen to be moving up or down, and to the influence of other regular patterns that may also be present in the figures. Therefore, each of these factors should also be evaluated before one can venture a forecast.

A knowledge of the 6-year pattern is offered to you as only one—albeit perhaps the most important—of the many factors that must be taken into account in making an actual forecast.

Longer Wave in Automobile Sales

The 6-year moving average shown by a broken line in Fig. 2 has the effect of eliminating any 6-year wave that may be present in the figures. When the 6-year wave is eliminated we can see the longer rhythms, if there are any, more clearly.

If you will look closely at the broken line in Fig. 2 you will see that it does in truth seem to undulate. There is clearly a crest in 1927, and 1938, 11 years later, is also a crest, although you cannot be sure just when the crest would have come if there had been no war.

As you go back in time you see another crest in 1915, and a fainter one about 1904. The behavior looks suspiciously as if there were an 11- or 12-year rhythm present in the figures in addition to the 6-year rhythm. This possibility is strengthened by the unusual strength which we have had in 1949 and 1950, which would be in accordance with such a pattern.

I shall report upon this matter for you at greater length in later reports.

CYCLES—Report for October

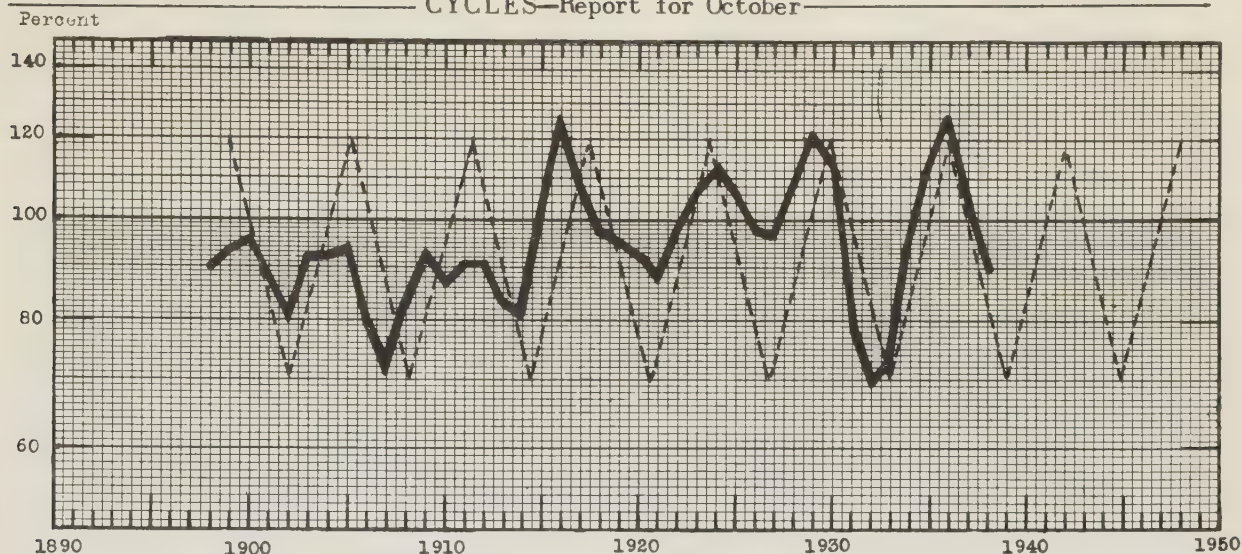


FIG. 3. 6-YEAR RHYTHM IN FACTORY SALES OF PASSENGER AUTOMOBILES 1895-1941. THE 3-YEAR MOVING AVERAGE EXPRESSED AS A PERCENTAGE OF THE 6-YEAR MOVING AVERAGE TREND. THE BROKEN LINE IS A DIAGRAMMATIC REPRESENTATION OF A PERFECTLY REGULAR 6 1/8-YEAR CYCLE.

TABLE 1

MOTOR VEHICLE PRODUCTION, U.S.A. 1893-1949

FACTORY SALES OF PASSENGER CARS

YEAR	No. IN THOUS.	3-YR. MOVING AVERAGE IN THOUS.	6-YR. MOVING AVERAGE IN THOUS.	PERCENT 3-YEAR MOVING AVERAGE OF 6-YR. MOVING AVERAGE	YEAR	No. IN THOUS.	3-YR. MOVING AVERAGE IN THOUS.	6-YR. MOVING AVERAGE IN THOUS.	PERCENT 3-YEAR MOVING AVERAGE OF 6-YR. MOVING AVERAGE
1893	ONE CAR	-	-	-	1922	2,274	2,456	2,525	97.2
1894	?	-	-	-	1923	3,625	3,028	2,856	106.1
1895	.3	-	-	-	1924	3,186	3,515	3,134	112.2
1896	.6	.7	-	-	1925	3,735	3,568	3,385	105.4
1897	1.2	1.4	-	-	1926	3,784	3,485	3,594	97.0
1898	2.4	2.5	2.8	89.4	1927	2,937	3,512	3,641	96.5
1899	3.9	3.8	4.0	92.9	1928	3,815	3,780	3,460	109.2
1900	5	5.3	5	95.1	1929	4,587	3,729	3,093	120.6
1901	7	7	8	84.4	1930	2,785	3,115	2,758	112.9
1902	9	9	11	79.5	1931	1,973	1,964	2,508	78.3
1903	11	14	15	91.3	1932	1,135	1,561	2,261	69.0
1904	22	19	21	91.9	1933	1,574	1,629	2,223	73.3
1905	24	26	28	93.5	1934	2,178	2,335	2,459	94.9
1906	33	33	42	78.6	1935	3,252	3,033	2,693	112.6
1907	43	46	65	70.8	1936	3,670	3,613	2,873	125.7
1908	63	78	93	83.6	1937	3,916	3,196	3,109	102.8
1909	128	124	135	92.0	1938	2,001	2,928	3,281	89.2
1910	181	169	197	86.1	1939	2,867	2,862	*	-
1911	199	245	272	90.3	1940	3,717	3,455	*	-
1912	356	339	376	90.2	1941	3,780	*	*	-
1913	462	454	552	82.3	1942	223	*	*	-
1914	544	634	793	80.0	1943	.1	*	*	-
1915	896	989	971	101.9	1944	.6	*	*	-
1916	1,526	1,389	1,119	124.2	1945	70	*	*	-
1917	1,746	1,405	1,331	105.5	1946	2,149	*	*	-
1918	943	1,447	1,493	97.0	1947	3,558	3,205	*	-
1919	1,652	1,500	1,603	93.6	1948	3,909	4,194	*	-
1920	1,906	1,675	1,821	92.0	1949	5,114		*	-
1921	1,468	1,883	2,165	87.0					

*NOT SIGNIFICANT. TOO DISTORTED BY WAR.

Wildlife Cycles

THE 9.6-YEAR CYCLE OF LYNX ABUNDANCE

In Fig. 1 herewith you can see the 9.6-year cycle of lynx abundance from 1735-36 to 1948-49. There are 22 complete repetitions of the cycle.

The irregularities which characterize the curve from 1778-79 to 1790-91 are attributed by Elton and Nicholson to "a series of terrible pandemics of smallpox

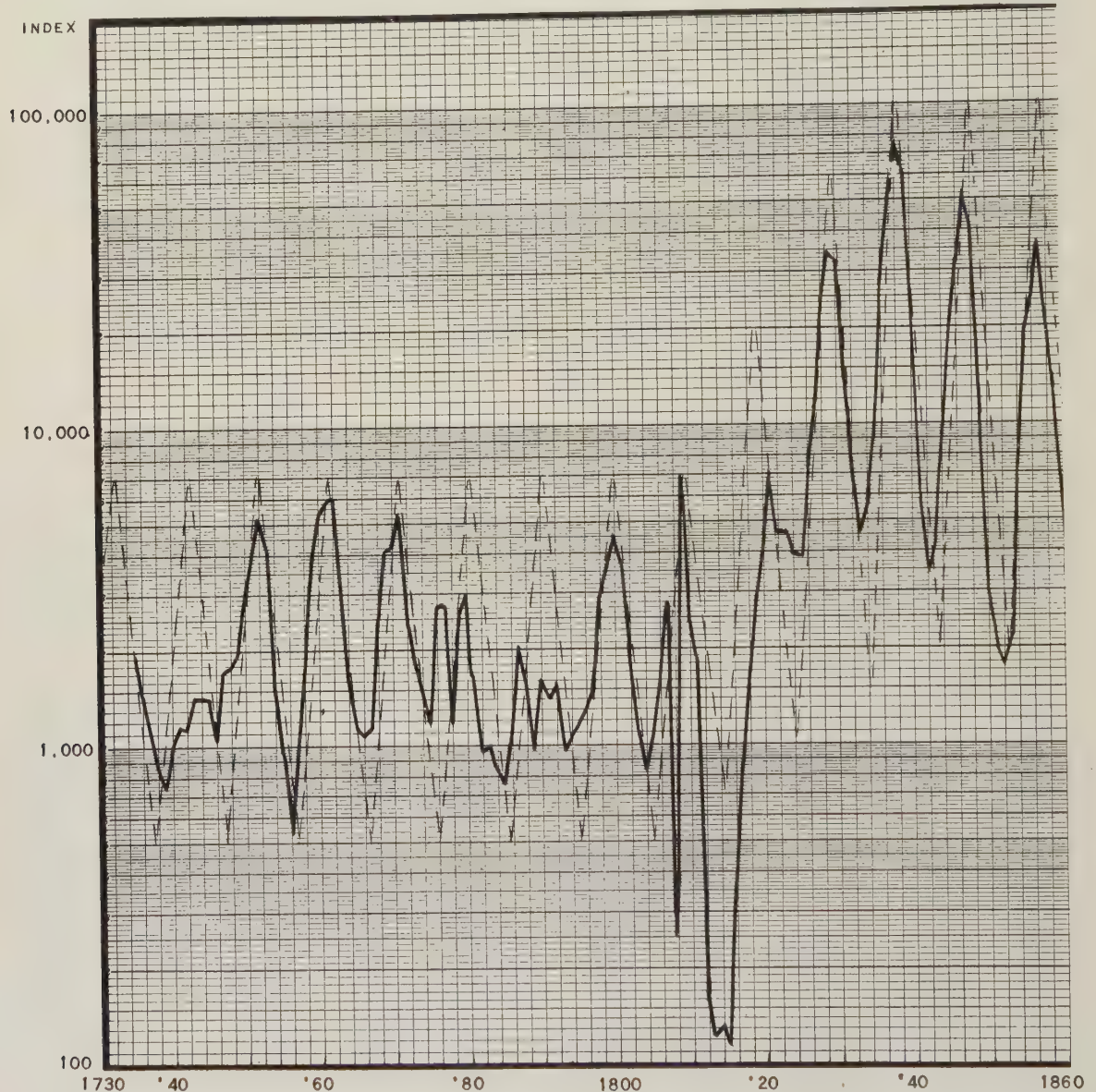


FIG. 1. AN INDEX OF THE ABUNDANCE OF LYNX IN CANADA (FOR DETAILS SEE TEXT). A 9.6-YEAR ZIGZAG HAS BEEN ADDED BY MEANS OF A BROKEN LINE. YEARS REFER TO "OUTFITS." AN OUTFIT

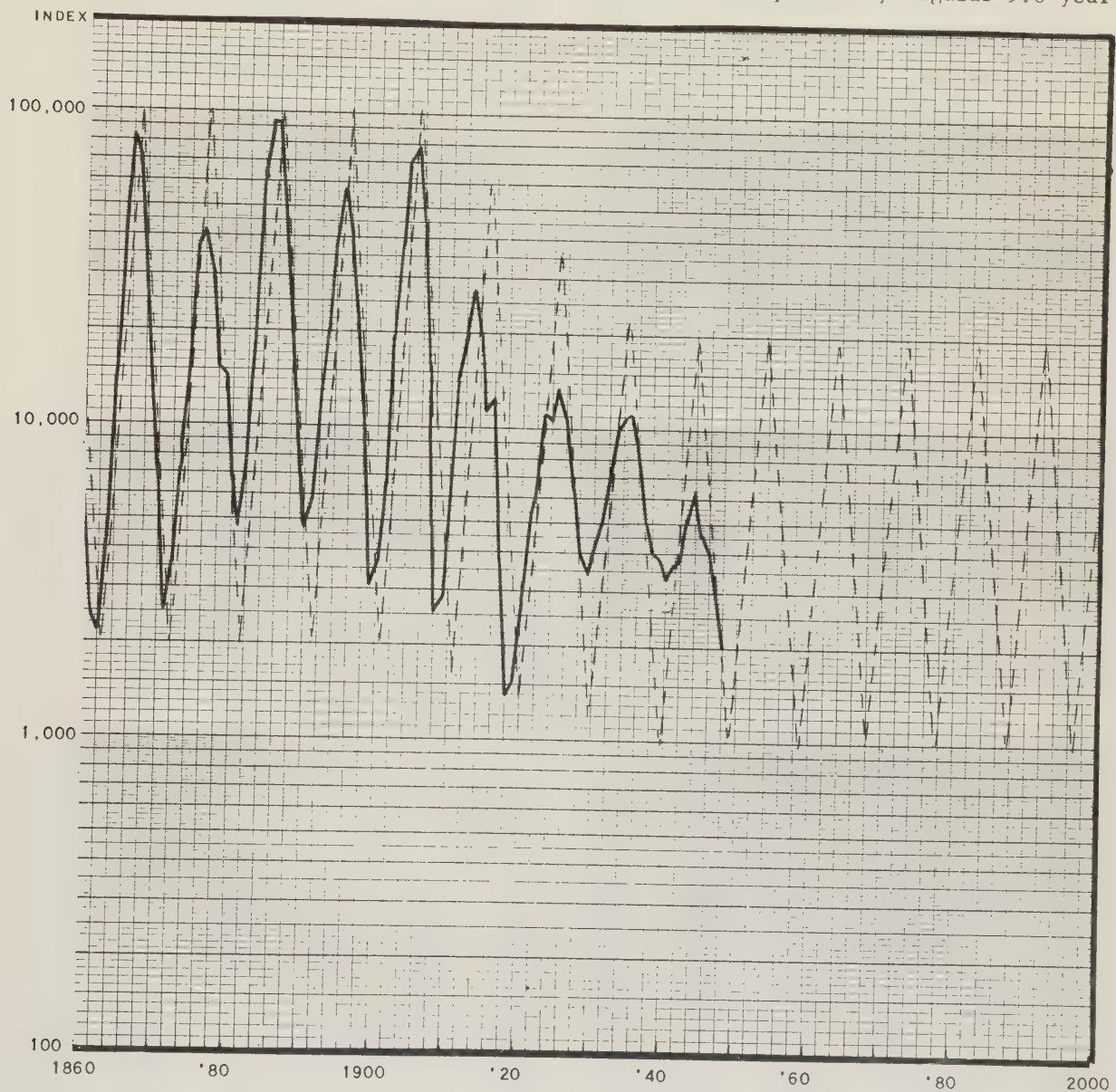
among the Indian tribes which partly destroyed the whole basis of the interior fur trade."

The gyrations of 1808-09 and 1809-10 are in my opinion the result of an error in dating. I suspect that a large part of the furs actually taken in 1808-09 were not recorded until 1809-10. I would suggest you use 3653, the average of the

values for 1808-09 and for 1809-10 for each of these two years as a closer approximation to the truth than the figure given.

I have not been able to find out what caused the drop from 1812-13 through 1815-16.

In Fig. 1 I have added by means of a broken line a perfectly regular 9.6-year



IS A FISCAL YEAR BEGINNING JUNE 1ST OF THE YEAR INDICATED AND ENDING MAY 31ST OF THE YEAR NEXT FOLLOWING.
(RATIO SCALE)

cycle to show you how amazingly the figures conform to an ideal pattern.

The curve shown in Fig. 1 is the longest numerical index of wild animal abundance that I know about.

In Table 1 you will find a new and never-before-published series of figures that you may wish to work with to determine as exactly as may be the true length of this cycle. Is 9.6 years the correct length, or is the length slightly over or slightly under 9.6 years?

You may also wish to study these figures to see what other rhythms are present. My own studies indicate that in addition to the 9.6-year rhythm apparent on the surface these figures show two additional underlying rhythms. One of these rhythms seems to be about 20 or 21 years long—

the other one seems to be about 35 or 36 years in length. I shall tell you more about them in later reports.

The Figures

This section about the figures is for reference only. You are not supposed to read it unless you are interested technically.

I should emphasize that the figures are an index. The index is made from various series, spliced together.

The figures are largely based upon a paper by Charles Elton and Mary Nicholson of the Bureau of Animal Population at Oxford. This paper is called "The Ten-Year Cycle in Numbers of the Lynx in Canada." It was published in the *Journal of Animal*

TABLE 1

AN INDEX OF LYNX ABUNDANCE 1735-1948

OUTFIT	INDEX	OUTFIT	INDEX	OUTFIT	INDEX	OUTFIT	INDEX	OUTFIT	INDEX	OUTFIT	INDEX
1735	1,958	1771	5,471	1807	2,788	1843	4,294	1879	14,554	1915	11,094
1736	1,464	1772	2,299	1808	277	1844	8,636	1880	6,642	1916	12,949
1737	1,111	1773	1,727	1809	7,029	1845	20,647	1881	4,708	1917	3,638
1738	899	1774	707	1810	2,593	1846	31,948	1882	7,220	1918	1,399
1739	740	1775	1,167	1811	1,884	1847	52,583	1883	22,879	1919	1,545
1740	990	1776	2,735	1812	167	1848	41,919	1884	61,570	1920	2,806
1741	1,164	1777	2,748	1813	122	1849	10,684	1885	93,121	1921	5,229
1742	1,119	1778	1,245	1814	131	1850	3,163	1886	91,704	1922	6,408
1743	1,444	1779	2,619	1815	116	1851	2,028	1887	46,755	1923	11,226
1744	1,410	1780	2,950	1816	347	1852	1,747	1888	22,107	1924	10,706
1745	1,399	1781	1,652	1817	845	1853	2,253	1889	9,739	1925	13,546
1746	1,022	1782	980	1818	1,533	1854	7,518	1890	4,765	1926	10,355
1747	1,699	1783	993	1819	2,901	1855	19,110	1891	5,703	1927	6,411
1748	1,760	1784	834	1820	4,128	1856	24,090	1892	12,902	1928	3,985
1749	1,947	1785	758	1821	7,094	1857	37,148	1893	20,331	1929	3,473
1750	2,846	1786	1,089	1822	4,581	1858	20,462	1894	36,853	1930	4,225
1751	4,010	1787	2,050	1823	4,579	1859	12,392	1895	56,407	1931	4,914
1752	5,359	1788	1,550	1824	3,952	1860	4,961	1896	39,437	1932	6,987
1753	4,197	1789	970	1825	3,818	1861	2,433	1897	21,826	1933	9,979
1754	1,410	1790	1,603	1826	7,426	1862	2,174	1898	10,071	1934	10,904
1755	956	1791	1,400	1827	11,012	1863	4,273	1899	3,028	1935	11,122
1756	530	1792	1,546	1828	24,344	1864	13,941	1900	3,712	1936	8,687
1757	918	1793	989	1829	35,263	1865	39,576	1901	6,654	1937	5,219
1758	1,738	1794	1,092	1830	33,330	1866	84,234	1902	19,770	1938	4,016
1759	3,842	1795	1,160	1831	13,784	1867	72,430	1903	39,122	1939	3,701
1760	5,296	1796	1,307	1832	6,758	1868	37,447	1904	68,672	1940	3,311
1761	5,820	1797	1,471	1833	4,559	1869	12,582	1905	78,749	1941	3,521
1762	6,017	1798	2,878	1834	5,697	1870	6,229	1906	43,066	1942	3,767
1763	2,892	1799	3,732	1835	9,233	1871	2,505	1907	10,896	1943	5,051
1764	1,759	1800	4,495	1836	27,711	1872	3,621	1908	2,547	1944	6,107
1765	1,138	1801	3,658	1837	50,830	1873	8,570	1909	2,783	1945	4,625
1766	1,086	1802	2,083	1838	78,563	1874	14,778	1910	6,326	1946	4,037
1767	1,129	1803	1,091	1839	61,821	1875	37,669	1911	14,728	1947	3,260
1768	2,507	1804	820	1840	22,653	1876	42,112	1912	20,015	1948	2,036
1769	4,104	1805	1,052	1841	5,723	1877	30,332	1913	27,875		
1770	4,329	1806	1,588	1842	3,406	1878	15,435	1914	19,485		

Ecology, Vol. II, No. 2, pp. 215-244, November 1942.

All figures are for "outfits." An outfit is a fiscal year beginning June 1st and ending the following May 31st. Thus the figures given for outfit 1735 are really for the fiscal year ending May 31st, 1736. All figures have been adjusted by Elton and Nicholson into the outfit in which the lynx were probably caught.

Figures from outfit 1735 through 1799 are from the original account books of the Hudson's Bay Company except for outfit

outfits 1892 through 1896 are from J. W. Jones *Fur-Farming in Canada* (second edition, revised and enlarged) Ottawa, 1914, as reported and redated by Elton & Nicholson.

There are no Northern Department or Hudson's Bay Company figures for outfit 1914. The figure in the table is an arbitrary figure halfway between the values for outfit 1913 and outfit 1915. There is some basis for such an interpolation. For example, there are outfit 1914 figures for the MacKenzie River District. They lie between the values for outfits 1913 and 1915.



THE LYNX FEEDS LARGELY ON THE SNOWSHOE RABBIT OR VARYING HARE.
THE VARYING HARE ALSO HAS A 9.6-YEAR CYCLE OF ABUNDANCE.

1778, and outfits 1787 to 1793 inclusive, for which years they are from H. Poland, *Fur-Bearing Animals in Nature and in Commerce*, London, 1892 as reported and redated by outfit by Elton & Nicholson.

Figures for outfits 1800 through 1820 are from Poland redated as above.

Figures for outfits 1821 through 1934 (except outfits 1892-6, and outfit 1914) are lynx fur returns, Hudson's Bay Company, Northern Department, as compiled by Elton & Nicholson, times 1.463 to make them comparable with the published Hudson's Bay Company total lynx figures. Figures for

Figures for outfits 1935 through 1939 are total collection of lynx furs, Dominion Bureau of Statistics, all of Canada, as reported by Elton & Nicholson, times .4953 to make them comparable with the figures used earlier. Figures for outfits 1940 to 1948 were furnished by the Department of Statistics, Canada, and were multiplied by the same constant.

In view of the approximation of the shape of the cycle to the compound interest curve, you may prefer to work with the logarithms of the figures instead of, or in addition to, the figures themselves.

Physiological Cycles

THE DAILY CYCLE IN THE BODY TEMPERATURE OF BIRDS

Did you know that the body temperature of many kinds of birds varies as much as three or four degrees between daytime and night? In some sorts of birds—the eastern song sparrow, for example—the variation is often as much as five degrees.

Fig. 25 below is taken from a 202-page book by S. Prentiss Baldwin and S. Charles Kendeigh called **Physiology of the Temperature of Birds**. This book is one of the Scientific Publications of the Cleveland Museum of Natural History. It is one of hundreds of similar publications in the Foundation Library in regard to which I shall write you from time to time, if you wish.

Figs. 14, 17, and 22 show the daily temperature cycles for an eastern house wren, a robin, and a catbird.

The charts shown herewith are only four of 41 figures in Baldwin and Kendeigh's captivating study in regard to the body temperature of birds. Those who are interested to know more about the subject should write to the Museum for a copy of the entire study. The price is \$1.00.

From the standpoint of the student of cycles, a daily rhythm is of no especial interest, except as an item of general information. In the present instance for example, the rhythm being just 24 hours long, the ultimate cause is known. No

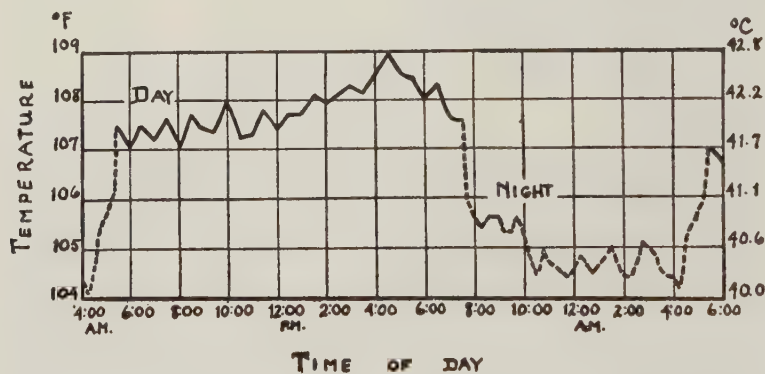


FIGURE 25.—AVERAGE DAILY RHYTHM IN BODY TEMPERATURE OF AN EASTERN WOOD PEWEE. This shows the effect of activity of the day (continuous line) against the quiet of the night (broken line).

Fig. 25 shows the Average Daily Rhythm in Body Temperature of an eastern wood pewee. During the day, when the pewee is active, the temperature ranges from 107 to 109. At night when the bird is dormant, the temperature ranges from 104 to 105.

Little minor cycles of about 80 minutes in length at night and about 72 minutes in length during the day are also observable, but these may be purely accidental variations. As far as I know, the shorter cycles in the fluctuations of bird temperature have never been studied.

special techniques are required for the statistical handling of the subject. The study is therefore really outside of the field of cycles, except in name.

How different if the observed rhythm had been 25 hours in length so that the peaks came one hour later each day! Or if Baldwin and Kendeigh had discovered that, after adjustment for the effect of the daily rhythm, a 14-day rhythm were also present! Here would have been something for a cycle student to get his teeth into. Finding perhaps a 25-hour or a 14-day rhythm in

the variations of barometric pressure or atmospheric electricity or some other environmental factor, he could then have called his part of the job finished and turned over his findings to the ornithologist to discover the cause and effect relation-

ships, if any, between the different phenomena with the same rhythm.

In respect to the daily cycle of variations in the body temperature of birds, however, the study really belongs entirely within the subject of ornithology.

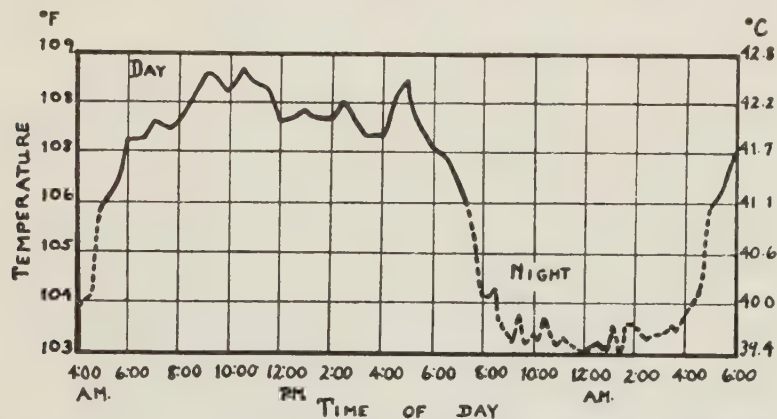


FIGURE 14.—AVERAGE DAILY RHYTHM IN BODY TEMPERATURE OF AN EASTERN HOUSE WREN (No. 1). This shows the effect of activity of the day (continuous line) against the quiet of the night (broken line).

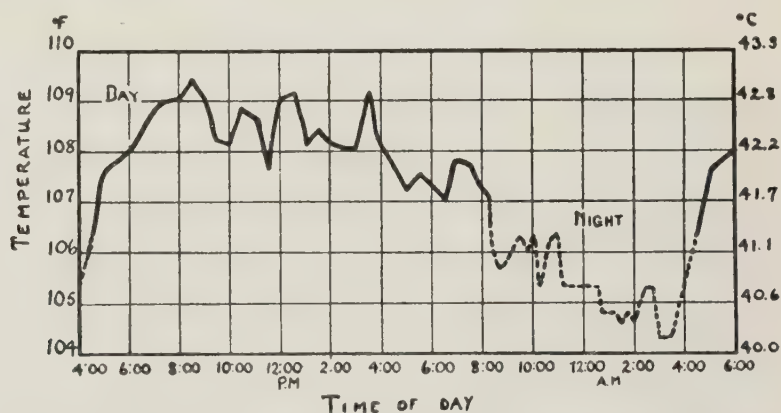


FIGURE 17.—AVERAGE DAILY RHYTHM IN BODY TEMPERATURE OF AN EASTERN ROBIN (No. 1). This shows the effect of activity of the day (continuous line) against the quiet of the night (broken line).

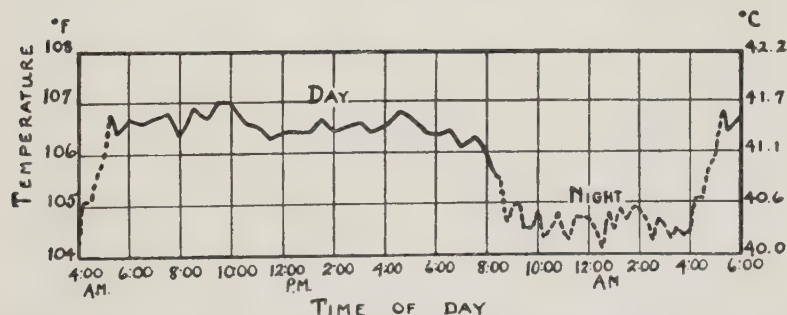


FIGURE 22.—AVERAGE DAILY RHYTHM IN BODY TEMPERATURE OF A CATBIRD (No. 2). This shows the effect of activity of the day (continuous line) against the quiet of the night (broken line).

Sociological Cycles

SEASONAL PATTERNS OF INSANITY, SUICIDE AND CRIME

I find that people are always interested to learn that there are twelve month or seasonal cycles in insanity, suicides, and crime, particularly sexual offenses.

Instead of writing you about these matters myself, I do not think I can do better than to quote three paragraphs written by Professor Huntington just before his death and to copy the chart he used to illustrate his remarks. The quotation* follows:

"As final evidence of the influence of the seasons on mental reactions, let us examine the seasonal distribution of outbreaks of insanity and crime. Abundant evidence is summed up in Fig. 50, which illustrates (1) the outbreak of insanity in Italy, England, the United States, and Germany; (2) suicide in Italy, France, and England, and (3) sexual offenses in France and Germany. Each of the sixteen curves (eighteen if we count the dashed lines for women) is at or near its maximum in June. All likewise, if smoothed to eliminate minor irregularities, show a minimum in winter. On an average the maximum in June is more than 80 per cent above the minimum in December. Homicides also are most numerous in June but remain abundant till autumn. Insanity, suicide, sexual crimes, and homicide all indicate mental weakness which causes people to do the wrong thing under conditions where stronger minds would behave differently. Curiously enough, these signs of weakness occur at just the time when other lines of evidence indicate well-being. June, as we have seen, is a time of good health and maximum conceptions, especially in western Europe. Children

conceived then or a little earlier live longer and are more likely to be eminent than those conceived at any other time.

"It is not difficult to understand why sexual crimes reach a maximum when the reproductive faculties are most active, but why do insanity and suicide also increase? The answer seems to be suggested in what was said in Chapter 16 (Section D) as to the excessive percentages of criminals, insane persons, and sufferers from tuberculosis conceived in June. At that time the physical stimulus which merely leads to health and increased powers of reproduction among normal people apparently overstimulates those who are poorly poised, weak of will, oversexed, or otherwise abnormal. Moreover, in the late spring many people who are physically below par and unable to produce children at other seasons appear to experience a reproductive stimulus which enables them to become parents. The results of the stimulus of the reproductive season upon both kinds of parents—the temperamentally weak and the physically weak—seems to appear not only in insanity, suicide, and crime among people of the parental generation, but in a crop of relatively handicapped children. These children suffer unduly from congenital defects. Like their parents, they are also the type which provides many individuals who experience nervous breakdowns leading to insanity or show the kind of lack of self-control which leads to crime. This, then, is what happens when people who are below par temperamentally or below the threshold of reproduction at most seasons are stimulated by the advent of the annual season of reproduction according to the animal cycle.

"On the other hand, among temperamentally normal people who are also normal in being well above the reproductive

*QUOTED FROM MAINSPRINGS OF CIVILIZATION BY ELLSWORTH HUNTINGTON. © 1945 BY JOHN WILEY & SONS, INC., REPRODUCED WITH PERMISSION.

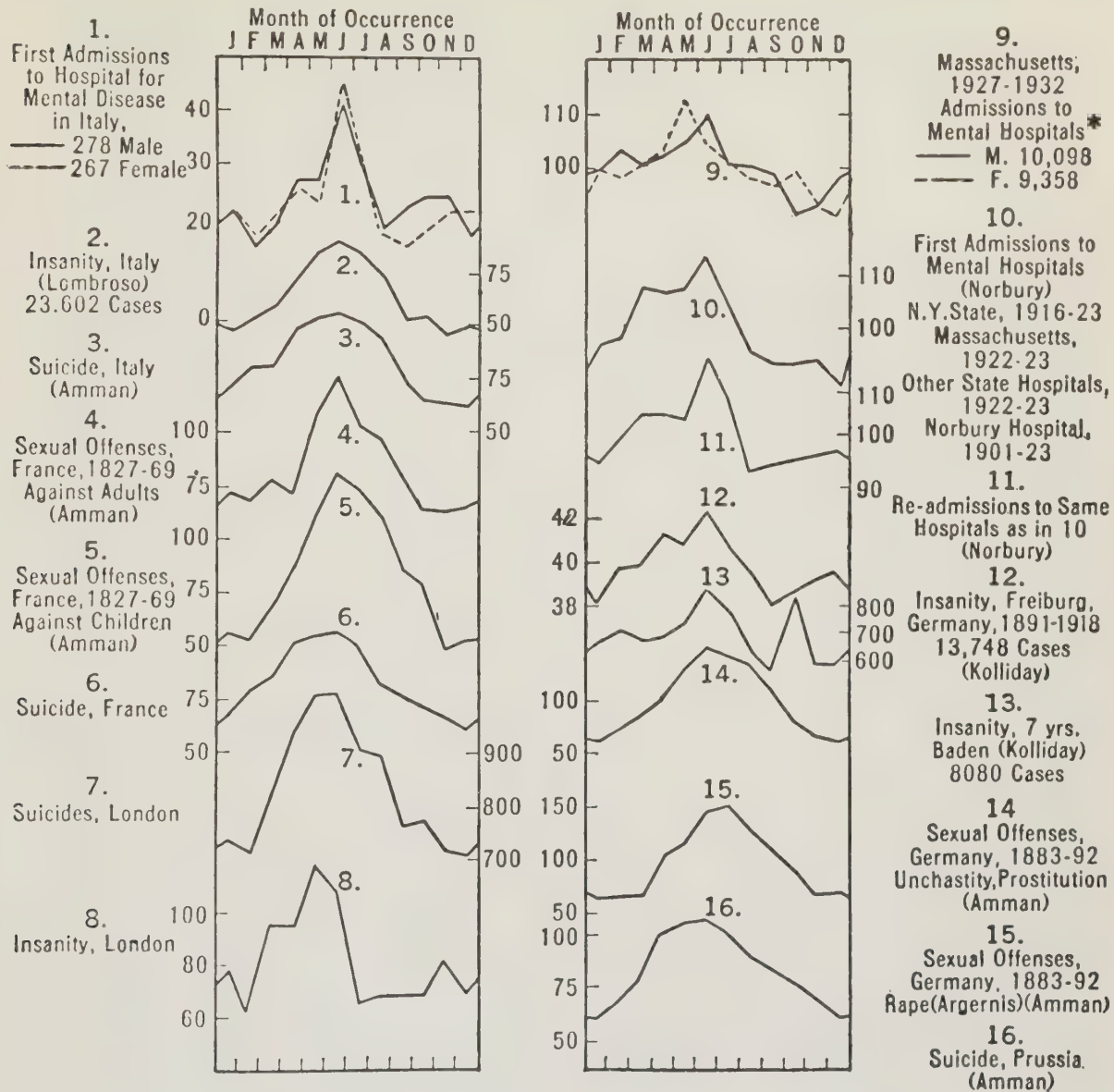


FIG. 50. SEASONAL INCIDENCE OF INSANITY, SUICIDE, AND CRIME. FROM Season of Birth.

threshold, the stimulation arising through the advent of the season of maximum reproductive capacity leads to the conception of children who are so vigorous that they raise the average span of life and provide much more than the normal proportion of leaders. Such relationships are significant as an indication that man's psychological as well as physical condi-

tions are powerfully influenced by the changing weather of the seasons. If this statement is correct, it seems logical to suppose that a corresponding psychological effect is produced by different types of climate and by different phases of climatic cycles. Thus again we see that human history and the progress of civilization must be closely tied up with climate."

Cycles In Cigarette Production

THE 8-YEAR RHYTHM, 1880-1948

What lies ahead for the production of cigarettes? This question is today uppermost in the mind of everyone interested in the tobacco industry, whether as a grower of tobacco, a manufacturer, or an investor.

This memorandum—and another which will follow it at a later date—sets forth some important facts which have a direct bearing upon this question.

In addition, dealing as it does with an important 8-year rhythm, this memorandum has a wider significance. As yet I have not told you much about the 8-year rhythm, but it is quite general and very important in many phenomena.

The 8-year rhythm had a low in 1932, and served to deepen the major depression of that year. It is noteworthy that it has a crest in 1952 and should serve to minimize the depressing effect of other rhythms due for a trough at that time.

But to get back to cigarettes:

First of all, the rate of growth of cigarette production has definitely slowed down—see Chart 1.

The growth of the industry over the years has been dramatic, but the fact that the curve no longer rises as rapidly as formerly immediately demonstrates for you that the rate of growth has been decreasing.

More precise information can be obtained if you make percentage comparisons. For example, from 1906 to 1907 production increased 16.8%; from 1926 to 1927, 8.4%; from 1936 to 1937, 7.0%; but from 1946 to 1947 only 5.6%.

Percentage growth of each year in comparison with the year before is shown in Table 1.

As they get older, all industries experience a falling-off in rate of growth. It is nothing to be particularly alarmed

about. However, a continuation in this falling-off is very definitely something to take into account in any forecast you make of the future.

Underlying Growth Trend Must Be Computed

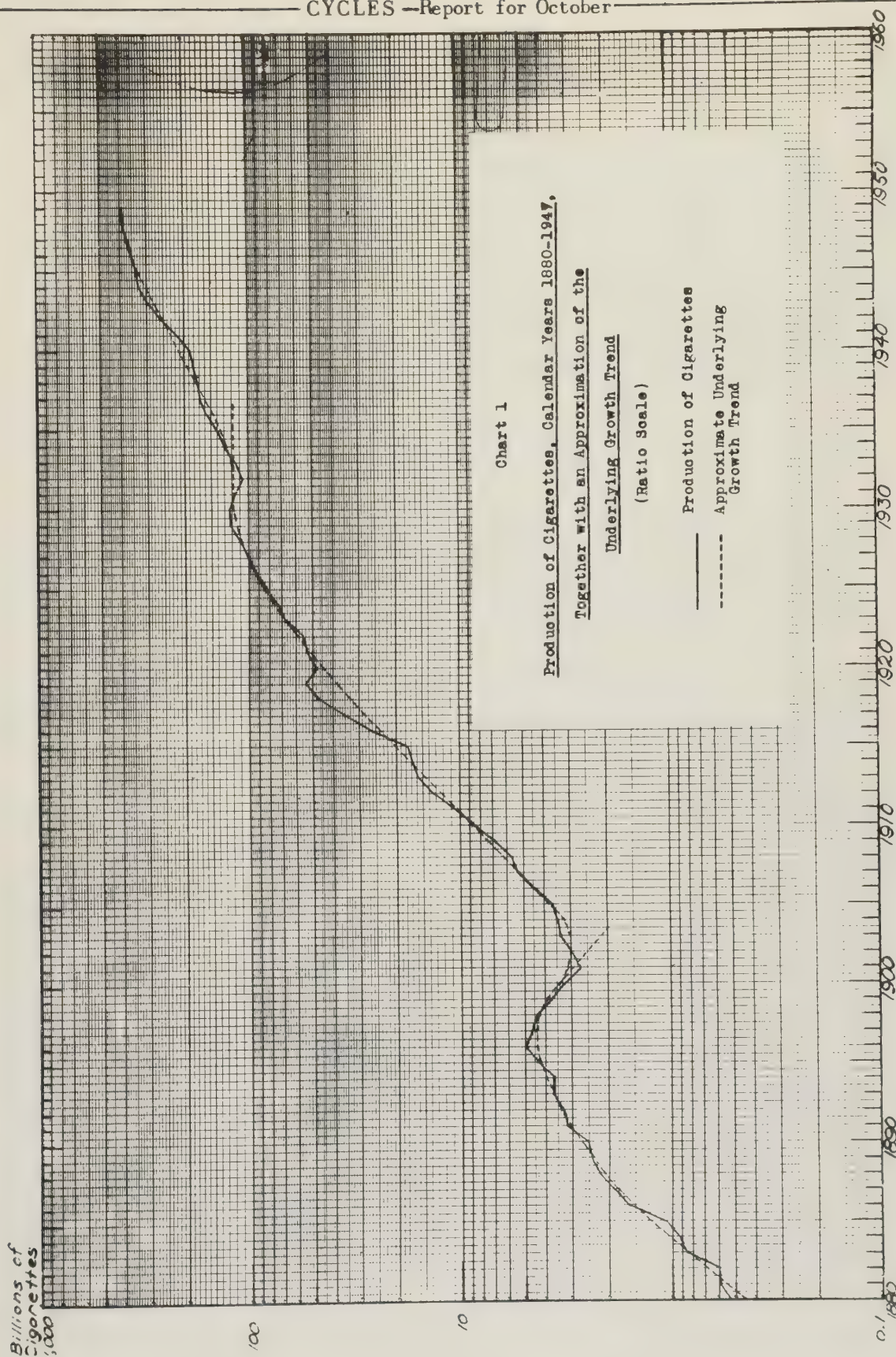
The various year-by-year fluctuations obscure the true growth tendencies of the industry. You must eliminate these fluctuations in order to determine the true underlying growth trend. An approximation of the underlying growth trend is shown by the broken line on Chart 1.

TABLE 1

THE PERCENTAGE
THAT EACH YEAR'S PRODUCTION OF CIGARETTES
IS OF THE PRODUCTION FOR THE PREVIOUS YEAR

YEAR	PERCENT	YEAR	PERCENT	YEAR	PERCENT
1880	---	1903	113.5	1926	112.0
1881	111.6	1904	102.0	1927	108.4
1882	100.7	1905	107.0	1928	108.9
1883	140.9	1906	122.7	1929	112.6
1884	109.0	1907	116.8	1930	101.2
1885	117.3	1908	109.3	1931	94.6
1886	148.9	1909	118.7	1932	91.0
1887	116.1	1910	126.8	1933	107.8
1888	118.6	1911	121.1	1934	113.1
1889	109.1	1912	125.8	1935	107.7
1890	103.8	1913	118.1	1936	113.5
1891	125.2	1914	108.4	1937	107.0
1892	104.6	1915	106.6	1938	101.0
1893	111.5	1916	140.8	1939	105.2
1894	98.9	1917	139.7	1940	104.8
1895	117.0	1918	132.1	1941	115.0
1896	117.2	1919	113.9	1942	118.2
1897	93.3	1920	89.3	1943	115.0
1898	94.6	1921	109.8	1944	109.3
1899	85.4	1922	107.0	1945	102.7
1900	87.0	1923	119.7	1946	105.4
1901	83.7	1924	109.0	1947	105.6
1902	108.7	1925	113.1	1948	104.2
				1949	*99.5

*PRELIMINARY



Three Stages of Growth

The underlying growth trend shows what appears to be three distinct stages. By 1896, all growth in the first stage appears to have ceased. In that year a decline set in that lasted until 1901. In 1901 a rebirth seems to have occurred, which got fully under way by 1905.

In the second stage, from 1901 to 1932, growth continued to be vigorous until 1923, at which time it began to slacken. By 1930, growth had ceased altogether.

It is interesting to note that if the rate of growth which prevailed from 1905 to 1923 had continued, 1947 production would have been ten times as great as it actually was.

After 1932, however, you can see evidence of a second "rebirth." Growth of the industry resumed, but at a much slower rate. This stage also seems to have begun to flatten. The industry is still growing, but it is growing at a decelerated pace.

Underlying Growth Trend Can Be Projected

When you have determined the underlying growth trend as accurately as possible, you can determine its characteristics, and these in turn can be used to project the trend into the future as the basis for a forecast.

To know exactly what the underlying growth trend is going to be in the years ahead is very valuable. But it is not enough. Modern management desires sales and production forecasts that are consistently accurate within a range of not over 1%. Therefore, it is necessary to forecast the wiggles or fluctuations around the underlying growth trend as well as the growth trend itself. There are facts that throw light on these wiggles.

A Regularly Recurring Pattern

Since the beginning, there has been a tendency for the volume of cigarette pro-

duction to go up and down, relatively, in a repetitive pattern that is 8 years from crest to crest—four years up—four years down. Important implications flow from this fact. For instance, from a knowledge of this 8-year tendency (and other regularly recurring tendencies that will be discussed later you can, within certain limits, forecast the probable relative fluctuations of future years.

Important Upward Force

The year 1948 was normal timing for a low year of the 8-year wave. If the prevailing pattern continues, 1950, 1951, and 1952 will be subject to an important upward force.

How can one venture to make such a statement? By relying upon the established fact that where there is regularity there is predictability. For example if, in a given business, the orders for the past six or eight summers have been high, one is justified in assuming that orders for this coming summer will probably also be high. At least it would be very foolish to ignore the possibility that business might develop in that way.

8-Year Pattern in Cigarette Production

You can see definite regularity in the history of cigarette production. The 8-year pattern in these figures has shown up without exception eight times during the past 68 years. Chart 2 not only shows this 8-year pattern clearly, but also shows how it will operate from 1948 to 1960 unless something comes into the picture to break the pattern of two-thirds of a century.

Chart 2 is based on the percentages that the production figures are of the approximate underlying growth trend. A dotted line indicates a perfectly regular 8-year repetitive pattern. This ideal pattern aids your eye to see deviations from perfect regularity that have been caused by other influences—either other regular

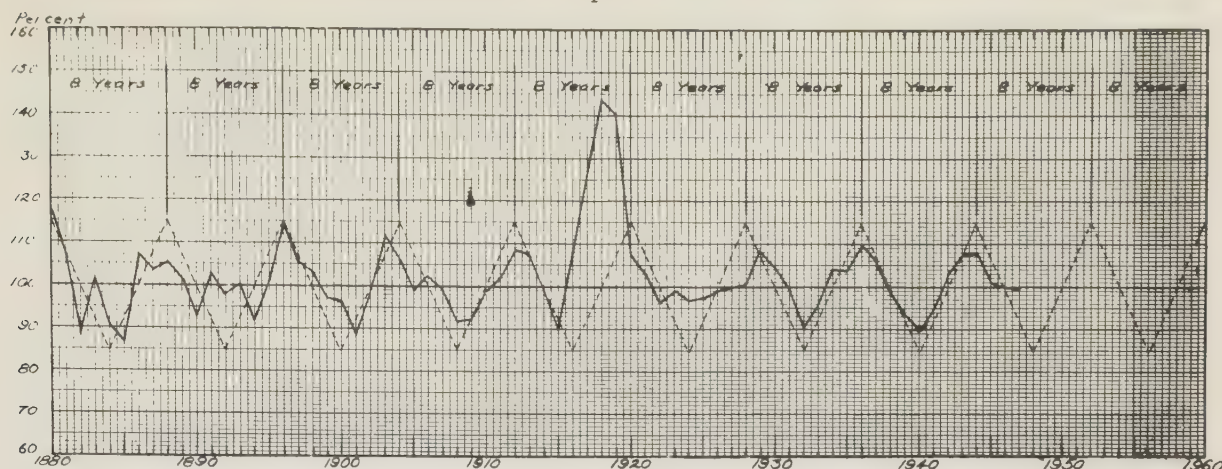


CHART 2. 8-YEAR REPETITIVE PATTERN IN CIGARETTE PRODUCTION, CALENDAR YEARS 1880-1949. DOTTED LINES REPRESENT, FOR COMPARISON, PERFECTLY REGULAR 8-YEAR CYCLE.

patterns, or non-recurring irregularities, or both. The conformity of the pattern to the ideal is noteworthy; it would be even better if the figures had been adjusted for a concurrent 6-year rhythm.

Characteristics of the 8-year Pattern

Study of the curve indicates the possibility that the waves are a shade longer than 8 years, but for purposes of this memorandum they will continue to be called 8 years long.

Average behavior of the actual annual figures has been as follows: From a normal year of high, 6.9% above trend, the production figures changed over a 4-year period to a normal year of low, 6.9% below trend, an overall move of 13.8%. This change amounts to a 12.9% decline; a 14.8% rise. Of course, if in these four years trend itself had advanced, say 15 to 20%, there was no actual decline—merely a slowing down in rate of growth.

Normal years of high for the 8-year pattern are 1888 and every 8 years thereafter, namely, 1896, 1904, 1912, 1920, 1928, 1936, 1944, 1952, 1960, and so forth.

Normal years of low occur in all instances four years later.

Out of the 17 highs and lows shown in the chart, 13 have come exactly on time or within one year of perfect timing.

Significance of the 8-Year Pattern

Granted that the 8-year pattern is there, is it significant?

The internal consistency of the 8-year tendency in cigarette production gives you every indication that it is a reliable pattern which can be used to forecast future probabilities. Furthermore, an average 8-year or slightly longer pattern has been recognized as being present in many other economic time series—some of them covering a much longer period of time than the cigarette industry has been in existence. Also average waves of similar length have been discovered in solar activity, in the thickness and thinness of successive tree rings, and in climate. It is possible that we are dealing here with something that is very fundamental. Unfortunately, enough work has not yet been done to see whether or not the lengths of economic and natural patterns are identical, and whether or not there is any interrelation between them. This is the task of the future. It will not be easy but it will be eminently worthwhile.

Regardless of the reasons for this and for other similar patterns, many executives now are depending, more and more, upon a knowledge of such regularities to throw light upon the future. It is obvious that anyone interested in the prospects of the cigarette industry has, in this type of analysis, a powerful tool with which to detect the probable fluctuations of future production and the underlying growth trend of the industry as well.

A Word of Caution

Just as the ocean tides can be overwhelmed by a hurricane, even though the tidal force continues, so also the repetitive 8-year pattern in cigarette production can be overwhelmed or modified by other forces.

Assuming that the pattern is still operating, it will be modified by the influence of the underlying growth trend and by the influences of other regular patterns and non-recurring events that may also be reflected in the figures. Therefore, each of these factors must also be evaluated before one can venture to predict cigarette production.

Forthcoming Discussion

In the article which will follow in a later monthly report, additional facts will be given which will help to answer the question, "What lies ahead for cigarette production?" In particular, the discussion will deal with the concurrent 6-year wave, and with the underlying growth trend, which is curving over sharply.

TABLE 2

PRODUCTION OF CIGARETTES# U.S.A., 1880-1949

YEAR	PROD. (000,000 OMITTED)	YEAR	PROD. (000,000 OMITTED)	YEAR	PROD. (000,000 OMITTED)	YEAR	PROD. (000,000 OMITTED)	YEAR	PROD. (000,000 OMITTED)
1880	532.7	1894	3,621	1908	5,743	1922	55,760	1936	158,900
1881	594.6	1895	4,238	1909	6,819	1923	66,720	1937	170,000
1882	598.8	1896	4,967	1910	8,644	1924	72,710	1938	171,700
1883	844.0	1897	4,632	1911	10,469	1925	82,250	1939	180,700
1884	920.3	1898	4,384	1912	13,167	1926	92,100	1940	189,400
1885	1,079.5	1899	3,742	1913	15,556	1927	99,810	1941	217,900
1886	1,607.3	1900	3,254	1914	16,856	1928	108,710	1942	257,500
1887	1,865.3	1901	2,723	1915	17,964	1929	122,390	1943	296,200
1888	2,211.9	1902	2,961	1916	25,290	1930	123,800	1944	323,600
1889	2,413.3	1903	3,360	1917	35,331	1931	117,100	1945	332,200
1890	2,505.2	1904	3,427	1918	46,657	1932	106,600	1946	350,000
1891	3,137.3	1905	3,667	1919	53,120	1933	114,900	1947	369,700
1892	3,282	1906	4,501	1920	47,430	1934	130,000	1948	386,800
1893	3,661	1907	5,256	1921	52,090	1935	140,000	1949	*385,000

#ALL CIGARETTES PRIOR TO 1898; CIGARETTES WEIGHING LESS THAN 3# PER 1,000, 1898 TO DATE.

*PRELIMINARY

SOURCE: AMERICAN TOBACCO COMPANY AND COLLECTOR OF INTERNAL REVENUE

Technical

HOW TO GET HINTS OF CYCLES THAT MAY BE PRESENT IN A SERIES OF FIGURES

In Two Parts - Part II

In the September report I described for you four graphic methods for obtaining hints of cycles that might be present in a series of figures. I also described five of the computational methods.

In this section of the outline, I want to tell you about six other computational methods that are useful and also to describe briefly some of the machines that have been used to minimize the labor of computation.

Let us then pick up the story where we left it last month and proceed to the consideration of the tenth item on our outline.

10. **Elimination of trend.** There are, of course, a variety of methods of determining trend and, upon occasion, almost any of these will be useful in helping to get hints of cycles that may be present in the data.

For a discussion of many ways of trend determination, refer to Croxton and



FIG. 102. Tide predictor of the United States Coast and Geodetic Survey.

Cowden's *Applied General Statistics*, pps. 363-463. Having determined the trend, one should remove it by dividing each point on the curve by the corresponding value of the trend.

However, as an aid in finding hints of cycles, probably the best form of trend to use is the moving average even though, from other points of view, the moving aver-

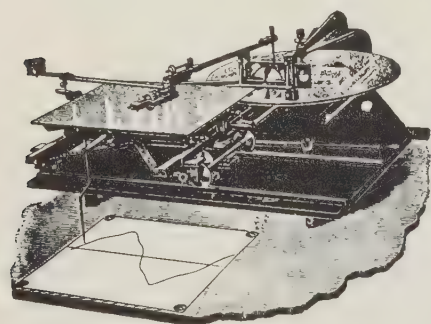


FIG. 104. Rowe's harmonic analyzer.

age may be one of the worst forms of trend to use. Comparison of the actual data with the moving average will emphasize certain rhythms at the expense of others and will often reveal cycles that might be otherwise almost completely hidden. This method has the added advantage that you can know the effect of the manipulation upon all regular cycles that may be present in the series.

For a description of the effect of comparing the actual data with their moving averages, see the Foundation's *Technical Bulletin No. 4*.

11. Comparing one moving average with another is another means by which you can manipulate the data to reveal hidden rhythms. But here also, as always, you need to be on your guard in interpreting your results.

12. Getting slightly more complicated, you may now wish to make a series of periodic tables.

A Periodic table is merely a table with as many columns as there are items in the cycle being studied and as many lines as

there are possible repetitions of the waves. Into this table you post the data consecutively.

For a rudimentary outline of the periodic table, you might refer to Croxton and Cowden's *Applied General Statistics*, pps. 554-562, Prentice Hall, 1941.

For a better description of the periodic table, you could examine a chapter called "Analysis of Non-Harmonic Periodic Functions" in a book by Worthing & Geffner called *Treatment of Experimental Data*, John Wiley & Sons, 1943.

From the amplitude of a sine curve fitted to the averages of the columns one can get some idea of the relative importance of the average wave with a period equal to that of the table.

By dividing the table horizontally into halves, thirds, or other fractions and taking subtotals of the columns, one can get some idea of the continuity of the given average wave throughout the series.

If the crests and troughs of the average wave in each section slip slightly forward or back in relation to the section before, one has a hint that the rhythm, if present, is slightly longer or shorter than the given length.

If the nature of the data permits, numbers above the trend or above 100 can be recorded in black, the others in red. In such a table bands of color running diagonally across the page will often reveal hints of rhythms that may be present of lengths other than the length of the table.

13. Harmonic analysis will give you hints of cycles that may be present. If done by a mechanical or electrical analyzer, it is very easy. For an excellent description of the principles involved, see Dayton C. Miller's *The Science of Musical Sounds*, published by The Macmillan Company in 1937. This book also gives an extended description of mechanical harmonic analysis.

Before making a harmonic analysis you must correct for trend. Harmonic analysis

gives you the amplitude (height) and phase (position in time) of the waves that may be present **on the average** in the series as a whole, after corrections for trend, and for each of the parts when averaged by halves, thirds, fourths, fifths, sixths, etc. In harmonic analysis the waves are assumed to be sine shaped, but of course they may not actually be of this shape.

Unless the data are truly repetitive, as with a sound wave, cycles obtained by harmonic analysis are merely mathematical building blocks, and have no necessary relations to reality. We merely know that when combined they will reproduce the original wave, but for purposes of forecasting, one might as well project a photostat of past behavior

Although you will often find the hints developed by harmonic analysis of use in finding rhythms that may be present in the figures, you can get much better results by a method that I have christened **Multiple Harmonic Analysis**. As far as I know, it has never been described in print, and so I cannot give you any references to books or articles where you can read about it in detail, but in principle it is very simple. You merely make successively a number of harmonic analyses (perhaps 8 or 10) of shorter and shorter sections of the original data. For example, if your series consisted of 200 figures, you might make one complete harmonic analysis of them (as far down the scale as your machine would go), then another complete harmonic analysis of the first 198 figures, then a third one of the first 196 figures, and so on, choosing lengths according to your particular needs.

Multiple harmonic analysis will give you many more points on your periodogram—ten times as many points if you make ten analyses. A periodogram of this sort (with ten times as many points) is really useful and will point out possibilities of real cycles instead of merely recording mathematical abstraction.

(A periodogram is merely a chart on which, after due adjustment, you record

the amplitude of the average waves at various wave lengths. In other words, it is a spectrum.)

14. One of the best ways to get hints of cycles is to adjust for and eliminate cycles already found, just as you would adjust for a seasonal cycle.

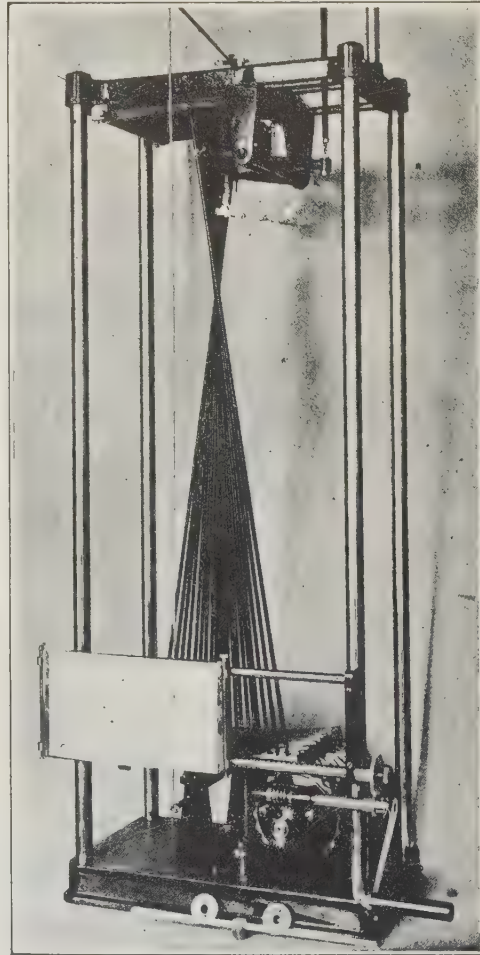


FIG. 103. Michelson's harmonic analyzer and synthesizer for twenty components.

15. No account of methods of finding hints of rhythms would be complete without reference to the methods developed by Dr. Norbert Wiener. These methods were restricted during the war but the restriction has been lifted and the methods are described in a book by Dr. Wiener entitled **Extrapolation, Interpolation, and Smoothing of Stationary Time Series** published jointly

by the Technology Press of the Massachusetts Institute of Technology and John Wiley & Sons, Inc., New York, in 1949.. These methods attempt to extrapolate any regularities present in a series of figures, together with a measure of the probability of the accuracy of the extrapolations.

The description of the method is quite complicated and unless you have a good mathematical background, these methods are probably better read about than attempted.

MACHINES

1. A discussion of **optical machines** is more or less academic, for there are only two such machines that I know about, one in Tucson, Arizona, and the other in Chicago.

The Arizona machine was invented by Andrew E. Douglass in 1914 and is described in "The Cyclograph: Variable Grating Type" in **Reports of the Conferences on Cycles**, Carnegie Institution of Washington, 1929, pps. 34-40.

The Chicago machine was developed independently some thirty years later by L. V. Mitelman. It operates along more or less the same lines.

2. The most important of the **mechanical machines** used to get hints of cycles in a series of figures or curves are the harmonic analyzers. These were touched upon above in the section on harmonic analysis. The best one that I know about is manufactured by the Mico Instrument Company of Cambridge, Massachusetts. The latest model costs \$12,500. We would like one, so, if you are feeling generous.....!

In addition, I should perhaps mention a machine developed by C. G. Abbot for the mechanical resolution of curves. You will find it described in Smithsonian Miscellaneous Collections, Vol. 87, No. 4, under the title **The Periodometer: An Instrument For Finding and Evaluating Periodicities in Long Series of Observations**. I suspect the machine was not too satisfactory.

3. A fairly large number of **electrical machines** for obtaining hints of waves that may be present in curves have been developed.

One of these has been described by R. L. Wegel and C. R. Moore in an article entitled "An Electrical Frequency Analyzer," published in the April 1924 issue of the **Bell System Technical Journal**.

Another machine has just been developed by H. Bruderlin of Los Angeles. It was first put into use in May of this year.

Samuel F. Bagno and Charles C. Works of New York have also built a machine for electrical resolution. This machine was demonstrated at the June 27th meeting of the Foundation for the Study of Cycles. (Refer to the September report, pages 29 to 32 inclusive, and to pages 28 and 29 of this report.)

Mitelman also has invented an electrical device for analyzing cycles. This machine was patented October 14, 1941, under patent 2,258,859. You can get a description of it from the patent office for twenty-five cents. Mitelman built a rather crude model to prove that the machine would work, which I saw in Chicago in 1942. I have not heard what he may have done since.

4. The use of **punch card and tabulating machines** for manipulating figures is too well known to require particular comment at this point. Vedder Hughey of Florida writes that he has devised a method for computing simple section moving averages by means of punch cards.

G. T. Lane writes that he has made a 39-term Macaulay weighted moving average of a series of 1100 figures recording water levels in Lake Ontario over a period of years in a total elapsed time of eight hours, including punching the cards and running them through the machines.

All of these machines are of use in minimizing labor, but often they involve more fuss and bother than the time they save is worth. Their use depends chiefly upon the quantity of work of this sort with which one is engaged, and the facil-

ities one has for carrying through on the results of the machine work.

* * * * *

Having used one or a combination of these methods to obtain a hint of the length of a rhythm that may be present in a series of figures or in a curve, your next step, as stated in the beginning, is to find out all you can about the indicated cycle. For example, you must find out the exact length of the cycle, its amplitude, its phase position, and its shape. More important than this, you must find out whether or not it is regularly repetitive, that is, rhythmic, or if it is a mere mathematical abstraction.

If it is rhythmic, you must then go further and come to an opinion in regard to its significance. That is, how many times out of a hundred could a rhythm of this regularity exist in a series of figures as a result of separate random forces. As

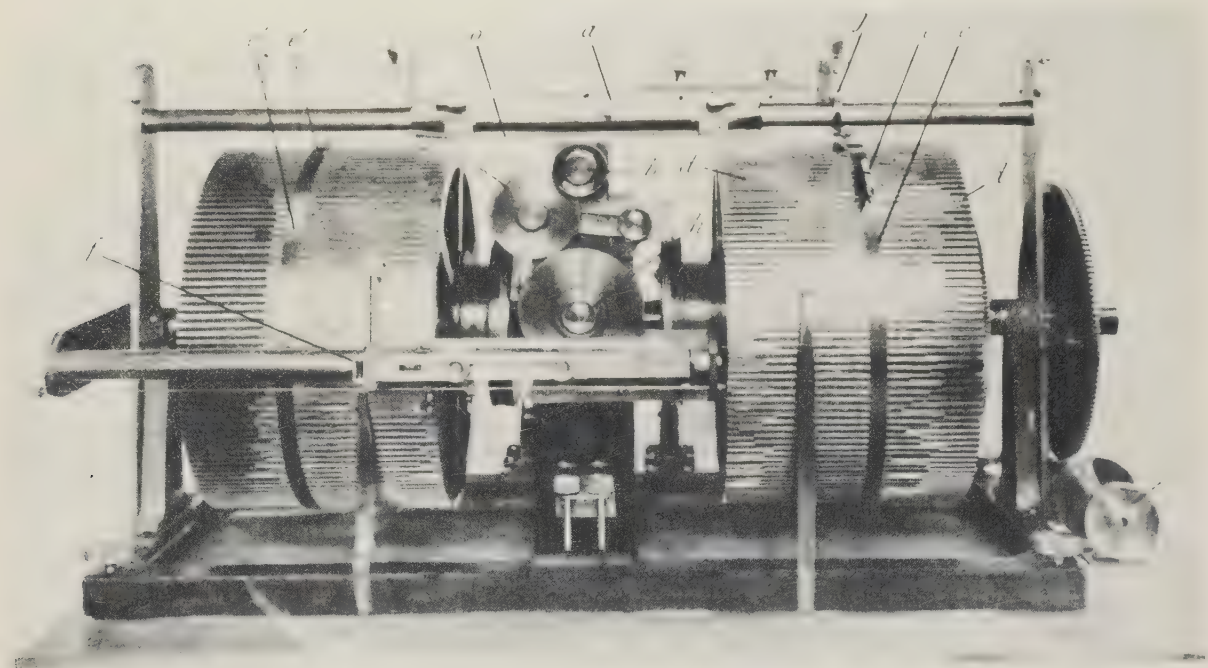
I have mentioned before, you can easily find rhythms in random figures. but such rhythms will not continue over many repetitions. The problem before you at this point is to decide the probabilities of the observed behavior having arisen from random forces that cannot be expected to continue or from some continuing force that probably will continue.

Both of these two additional steps are beyond the scope of this outline but it will be treated in later monthly reports.

Acknowledgment: All of the pictures in this article, except the one immediately below, are taken, with the permission of the Case School of Applied Science from Dayton C. Miller's book **The Science of Musical Sounds**, © The Macmillan Company, 1916. The picture below is taken from one of the Smithsonian Institution publications, as indicated.

SMITHSONIAN MISCELLANEOUS COLLECTIONS

VOL. 87 NO. 4, PL. 1



THE PERIODOMETER

THE BAGNO-WORKS ANALYZER AND SYNTHESIZER

You will remember that in the September issue, under the heading **Foundation Affairs**, I told you about the Bagno-Works electric analyzer and synthesizer that was demonstrated at the summer meeting of the New York Chapter of the Foundation.

I did this so that if you came to the meeting you would have a written record of what you had heard and so that if you could not come to the meeting you could know all about the machine too.

You will remember that in the September report, I said that Mr. Bagno and Mr. Works really had a group of parts that could be assembled into any one of four machines. I described Machine I which makes any moving average of any time series of up to 100 terms, Machine II, which compares the curve with its moving average, or compare any moving average of a curve with any other moving average of the same curve, and Machine III, which gives the relative correlation between two curves. Space forbade a description of Machine IV. I told you I would tell you about it in this report.

You will remember that in speaking of Machine IV in the last issue, I said that it "finds probabilities of average waves, synthesizes them for comparison with the original curve, and projects them, singly or in combination, into the future."

Machine IV is like Machine II in that it consists of two television transmitting cathode ray tubes, electric eyes, and amplifiers. Also, like Machine II, Machine IV has one inverter to turn the current from one electric eye upside down so that the electric impulses sent forward from the first eye can be subtracted from those sent forward from the second (see Fig. 4.) This hookup in effect subtracts the curves being broadcast from tube A_2 from the

curve being broadcast from tube A_1 .

Machine IV differs from Machine II however, in that the second tube, A_2 , does not have in front of it a duplicate of the silhouette of the curve to be studied but has instead a variety of ideal waves for comparison.

It also differs from Machine II in that, like Machine III, it has a meter.

In essence then, Machine IV subtracts from the curve to be analyzed the light passed by seven ideal rhythmic cycles selected out of a series of 2,000 such standard cycles. Then the machine, by means of the meter, records the combination of curves which shows the least difference, that is, which most nearly describes the original curve.

(In Fig. 4, for the sake of simplicity, only three ideal curves are shown on the face of tube A_2 . In practice, however, seven ideal curves can be shown simultaneously. The curves are printed on long strips of transparent tape which winds and unwinds from spools (not shown) on either side of tube A_2 .)

The machine will show you on a screen the shape of the synthesis or combination of the seven ideal cycles selected from the array of 2,000 available master cycles.

The machine will compare the ideal cycles with the entire curve to be analyzed, or part of the curve to be analyzed.

By turning a knob the scanning beam can be made to scan a continuation of the ideal cycles and thus in effect project for you into the future, or into the past, each of the seven selected rhythms, or any or all of them in combination.

If you make the original analysis of part of the curve only, you can compare the projected synthesis of the ideal cycles with the part of the curve not used in the

analysis, as a proof of the continuation of the cycles..

Whether you analyze the entire curve or only part of it, you can project all seven cyclic components, singly or in combination, into the future to show what will happen if the cycles are real and continue. This projection takes the form of a curve on the oscilloscope which you can observe or photograph or copy on tracing paper.

The machine is not limited to harmonic functions.

You can manipulate any standard wave being compared for goodness of fit not only for period (length), but for phase (timing) and for amplitude (height).

As you can compare each of 2,000 standard waves for period, phase, and amplitude it is likely to take you some little time to get the seven ideal waves that fit best. Mr. Works tells me that three or four hours are necessary to set the machine up for an analysis.

An inherent limitation of the machine is that it does not reveal to you whether

or not cycles which it "discovers" are merely average cycles or are truly rhythmic or repetitive cycles, but, as far as I know, no machine will do this.

The limitation is partly offset however, by the fact that the machine will tell you if the wave is present on the average in both first and second halves, or in first, second, and third thirds, etc., and can determine the sharpness of definition of phase, amplitude, and period.

Also, by projecting a synthesis of the "discovered" waves onto another part of the curve, one can get convincing evidence of a forecast.

A second limitation of the machine in its present state is due to mechanical imperfections which can doubtless be overcome in time. I refer to lack of complete definition and accuracy, fuzzy projection lines, etc.

Nevertheless the machine makes a very interesting addition to the various devices of this sort that have been developed over the years.

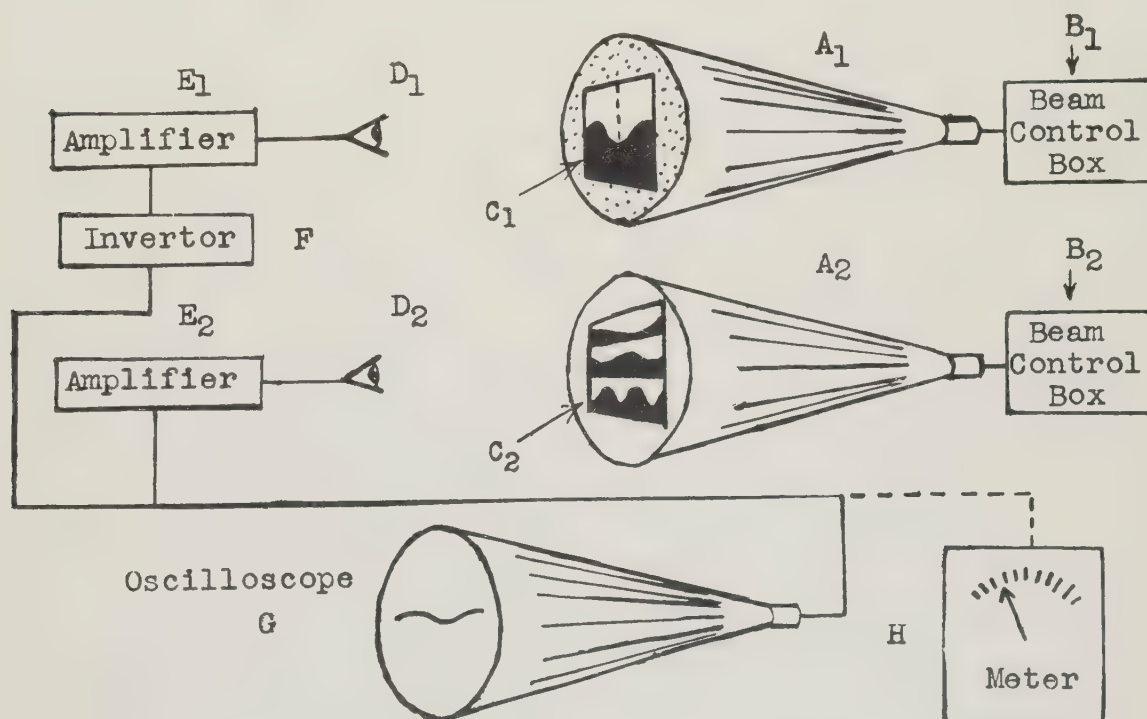


Figure 4

Questions and Answers

Question: I imagine that many of your subscribers are, like myself, primarily interested in your interpretation of the long-term stock market, real estate, and related business cycles. I would therefore prefer more frequent releases covering such subjects to those on tree rings, sun-spots, etc., which I have been receiving. Would this be possible?

Answer: I do appreciate your letter of August 3rd and I sympathize with your desire for more long-term stock market, real estate, and related business cycle studies.

Basically we are hammering out a new science. If it is to be accepted, it must receive the support and endorsement of natural as well as social scientists. If we ignore cycles in natural science, we cannot hope for the support of these people. Without their support we are doomed to perpetual ignorance in regard to the cause of these cyclic fluctuations.

Moreover, if we do not know the cause and the laws governing cycle lengths, etc., we are always on somewhat unstable ground in respect to the rhythms in business, stock market, and the other subjects that interest you.

I think if you will add up the material we have released and that we are releasing, you will find that economic subjects get about half our attention and that the thirty-six other disciplines involved in cycles have to share the other half of the attention between them.

Disregard the material that is of no interest to you and realize that if we did not publish it we would undermine our position as a scientific institution to the point of futility.

Question: In view of the fact that commodity prices, business and building activity and stock prices have seemingly gone counter to the predictions in **Cycles—The Science of Prediction** due to our preparations for war, I would like to have your opinion as to whether these developments invalidate in any way the principles taught in this book—or whether we are witnessing a change of trends during which these principles will continue to operate.

Answer: In my opinion the forces which have caused the cycles of the past are continuing to operate, and continuing to affect us, just as much as they ever did. I believe that these forces are physical and environmental forces.

I believe that they arise outside of the earth. I believe this because we find evidence of the same rhythms in solar phenomena.

I have no opinion as to whether or not these forces arise in the sun or arise outside of the solar system and affect both the sun and ourselves.

Our knowledge of these forces is as yet very imperfect. In addition to the distortions you speak of in your letter, there are doubtless distortions caused by other cycles we do not yet know about and by combinations of cycles. I do not know that the subject of cycles is as complicated as the subject of chemistry, but in our knowledge of cycles we are surely no further along than were the chemists back in the days of Lavoisier (1743-94), but even in those days, chemistry had made a start and we have now made a start in the study of cycles too. The job ahead is to try to make up for lost time.

Financial

THE FIRST EIGHT MONTHS OF 1950

As the Foundation is your organization, it is only proper that from time to time you should have a financial statement to tell you where our money comes from and where it goes.

So far this year of 1950, through August 31st, our receipts and disbursements have been as follows: (This statement does not include exchange items.)

Receipts - First 8 Months of 1950

Dues (we count as dues the first \$10 you pay)	\$3,308.69
Contributions (we count as contributions all over \$10 that you pay)	1,537.00
Sale of Books	505.38
Sale of Publications, Back Reprints, etc.	308.25
Fees for Research Work	1,490.00
Institute	300.00
Total	\$9,239.27

Disbursements - First 8 Months of 1950

Printed Material for Members	\$2,488.68
Office Expenses to Handle Memberships, Books, Sale of Publications, etc.	1,633.02
Office Expenses to Conduct Research and Prepare Reports for Members	2,621.47
Cost of Books Sold	410.91
Cost of Publications Sold, included in "Printed Material for Members"	---
Cost of Research Sold	609.25
Director's Salary (inc. Tax Payable)	2,666.66
Additions to Library	38.02
Equipment (Chiefly a second-hand Vari-Typer)	266.68
Total	\$10,734.69

Operating Loss, First 8 Months of 1950 \$1,495.42

If you have not paid your dues, please do so at once. If you can afford something in the way of a contribution in addition, it will be very welcome. If you have paid and wish to send an additional contribution, our joy will be unlimited!

Additions to the Library

"Rhythmic Behavior of the Nervous System," by Hudson Hoagland, a reprint from **Science**, Vol. 109, No. 2825, February 18, 1949, 8 pages, 7 figures. Gift of Dr. Hoagland.

"The Statistical Analysis of the Sunspot and Lynx Cycles," by P. A. P. Moran, a reprint from **The Journal of Animal Ecology**, Vol. 18, No. 1, May, 1949 2 pages, 1 figure. Gift of Dr. Moran.

"The Ten-Year Cycle in Numbers of the Lynx in Canada," by Charles Elton and Mary Nicholson, reprinted from **The Journal of Animal Ecology**, Vol. II, No. 2, pp. 215-244, November, 1942. Gift of Mr. Amory.

"Rhythmus und Periodik in der belebten Natur," by Albrecht Bethe, reprinted from **Studium Generale**, 2 Jahrg., Heft 2, 1949. Gift of Dr. Bethe.

Suomen Riista, 4, 170 pages. (In Finnish.) Suomen Riistanhoito-Saatio, Helsinki, 1949. Gift of the Game Research Institute of the Finnish Foundation for Game Preservation, Helsinki.

"An Ominous Drought," by Halbert P. Gillette, a reprint from **Water & Sewage Works**, March 1949 issue, 2 pages, 1 picture. Gift of Mr. Gillette.

Tree-Ring Hydrology in Southern California, by Edmund Schulman, University of Arizona Bulletin, Laboratory of Tree-Ring Research, Bulletin No. 4, Vol. XVIII, No. 3, Tucson, 1947, 136 pages, 11 tables, 9 figures.

Annual Report of the Forest Insect Survey, 1949. Gift of the Department of Agriculture, Canada.

"Jahreszeit und vegetatives Nervensystem," by Prof. Dr. B. de Rudder, from **Archiv für Kinderheilkunde**, Band 128, Heft 3, 1943, 14 pages.

"The Development of Social Physics," by John Q. Stewart, a reprint from **American Journal of Physics**, Vol. 18, No. 5, May, 1950, 15 pages, 6 figures. Gift of Dr. Stewart.

"Allgemeinbiologisches Zur Phanogenese Statischer Krankheitsgipfel," by B. de Rudder, from **Klinische Wochenschrift**, Jahrg. 22 10 Juli 1943, Nr. 28/29, S. 453/457, 15 pages, 4 figures. Gift of Dr. Rudder.

"Glacier Fluctuation for Six Centuries in Southeastern Alaska and its Relations to Solar Activity," by Donald B. Lawrence, a reprint from **The Geographical Review**, Vol. XL, No. 2, 1950, 33 pages, 18 figures. Gift of Dr. Lawrence.

"Estimating Dates of Recent Glacier Advances and Recession Rates by Studying Tree Growth Layers," by Donald B. Lawrence, from **Transactions, American Geophysical Union**, Vol. 31, Number 2, April 1950, 6 pages, 2 figures. Gift of Dr. Lawrence.

"A Creeping Drought Under Way," by Halbert P. Gillette, a reprint from **Water & Sewage Works**, March 1950 issue, 2 pages, 1 picture. Gift of Mr. Gillette.

"Zyklische Massenvermehrungen bei Vögeln und Klinsaugern," by J. Franz, from **Die Vogelwarten**, Band 15, Heft 3/1950. Gift of Dr. Franz.

Tree-Ring Hydrology of the Colorado River Basin, by Edmund Schulman, University of Arizona Bulletin, Laboratory of Tree-Ring Research Bulletin No. 2, Vol. XVI, No. 4, Tucson, 1945, 51 pages, 9 tables, 3 plates.

"What Tree Rings Tell," by Waldo S. Glock, a reprint from **News Service Bulletin of the Carnegie Institution of Washington**, Washington, D.C., Vol. IV, No. 20, Dec. 19, 1937, 8 pages, 3 figures. Gift of Carnegie Institution of Washington.

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- No. 2. CYCLES: LYNX AND FISH, MICE AND MEN—AND DOLLARS. An editorial, and CYCLES AS AN AID TO POST WAR PLANNING by the Director, reprinted from *General Electric Review* of May 1943, Volume 46, Number 5, (largely a condensation of Putting Cycles to Work in Science and Industry.) Format 8½" x 11", 10 pages, with 5 charts. Issued 1944. (Now out of print.)
- No. 3. EMOTIONAL CYCLES IN MAN, By Rex B. Hersey, Reprinted from the *Journal of Mental Science*. January 1931. Format 5½" x 8½", 22 pages. Issued 1944. Reissued 1946.
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- No. 6. MATAMEK CONFERENCE ON BIOLOGICAL CYCLES. A report by Ellsworth Huntington. Published 1932. Format 5½" x 8½", 16 pages with 1 chart. Issued 1944.
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- No. 10. SOLAR AND ECONOMIC RELATIONSHIPS by Carlos Garcia-Mata and Felix Shaffner, reprinted from *The Quarterly Journal of Economics*, Volume XLIX, November 1934. Format 5½" x 8½", 51 pages with 12 charts. Issued 1945. Reissued 1949.
- No. 11. PUTTING CYCLES TO WORK IN SCIENCE AND INDUSTRY—a popular lecture given by the Director before the McGill University chapter of Sigma Xi. This talk deals with rhythms in many fields, but chiefly with rhythms in business. Format 8½" x 11", 24 pages, with 21 charts and one illustration; published 1941. Reissued as a reprint in 1945.
- No. 12. TESTING CYCLES FOR STATISTICAL SIGNIFICANCE. A technical bulletin applying the Bartels test of significance to a time series cycle analysis. By Charles E. Armstrong. Format 5½" x 8½", 13 pages with 5 tables and 1 chart. Issued 1945 (Now known as Technical Bulletin No. 2)
- No. 13. DETECTION AND ISOLATION OF RHYTHMS—AN OUTLINE. Technical Bulletin by Edward R. Dewey. 5 pages, 1 table. Reissued 1945. (Now known as Technical Bulletin No. 1)
- No. 14. CYCLES, RHYTHMS AND PERIODICITIES. Reprinted from *Mainsprings of Civilization*, by Ellsworth Huntington, published by John Wiley & Sons, Inc., New York, 1945. Format 5½" x 8½", 24 pages, with 5 charts. Issued 1945. (Now out of print.)
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- No. 18. THE SUN MAKES THE WEATHER—2. Weather Effects of Solar Variation, by C. G. Abbot. Reprinted from *The Scientific Monthly*, April, 1946. Format 6¾" x 9¾", 8 pages, 3 charts. Issued 1946.
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- No. 21. FIELD MOUSE CYCLES (Life and Habits of Field Mice), by W. J. Hamilton, Jr. Reprinted from *The Scientific Monthly*, Vol. L, pp. 425-434, May, 1940. Format 6¾" x 9¾", 10 pages, 7 illustrations, 2 charts. Issued 1947.
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- No. 25. THE SUN'S SHORT REGULAR VARIATION AND ITS LARGE EFFECT ON TERRESTRIAL TEMPERATURES, by C. G. Abbot. Reprinted from *Smithsonian Miscellaneous Collections*, Vol. CVII, Number 4, April 4, 1947. Format 6¾" x 9¾", 33 pages, 9 tables, 12 figures. Issued 1948.
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- No. 30. RHYTHMS IN NATURE — DAILY, LUNAR, ANNUAL, AND SUNSPOT CYCLES, AND PERIODIC MIGRATION. Reprinted from *Animal Ecology*, by A. S. Pearse, published by McGraw-Hill Book Company, Inc., New York, 1939. Format 6¾" x 9¾", 25 pages, 3 maps. Issued 1949.
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